

THE PHLEBOTOMINE SAND-FLIES
OF WEST PAKISTAN
(DIPTERA : PSYCHODIDAE)



BY

D. J. LEWIS *xw*

Scientific Staff, Medical Research Council, London,
c/o British Museum (Nat. Hist.)

Pp. 1-57, 136 Text-figs., 1 Map

BULLETIN OF
THE BRITISH MUSEUM (NATURAL HISTORY)
ENTOMOLOGY Vol. 19 No. 1
LONDON: 1967

THE BULLETIN OF THE BRITISH MUSEUM (NATURAL HISTORY), instituted in 1949, is issued in five series corresponding to the Departments of the Museum, and an Historical series.

Parts will appear at irregular intervals as they become ready. Volumes will contain about three or four hundred pages, and will not necessarily be completed within one calendar year.

In 1965 a separate supplementary series of longer papers was instituted, numbered serially for each Department.

This paper is Vol. 19, No. 1 of the Entomological series. The abbreviated titles of periodicals cited follow those of the World List of Scientific Periodicals.

World List abbreviation: Bull. Br. Mus. nat. Hist. Entomology.

© Trustees of the British Museum (Natural History) 1967

TRUSTEES OF
THE BRITISH MUSEUM (NATURAL HISTORY)

Issued 16 January, 1967

Price £1 3s.

THE PHLEBOTOMINE SAND-FLIES OF WEST PAKISTAN¹ (DIPTERA : PSYCHODIDAE)

By D. J. LEWIS

CONTENTS

	<i>Page</i>
INTRODUCTION	3
METHODS	4
CLASSIFICATION	6
KEYS TO SPECIES KNOWN FROM WEST PAKISTAN	8
TAXONOMY AND DISTRIBUTION OF THE SPECIES	12
ZOOGEOGRAPHY	46
BIOLOGY	49
RELATION TO DISEASE	51
ACKNOWLEDGMENTS	52
REFERENCES	53
INDEX TO SPECIES AND SUBSPECIES	57

SYNOPSIS

Some aspects of classification are discussed, and keys to the known species are given. Most of the species are described or redescribed, and distribution lists are provided. Zoogeography is discussed with special reference to the 29 species and one local subspecies found hitherto. The interpenetration of eastern and western faunas has been increased by the Himalayan mountain system. Notes are given on aspects of biology and relation to human disease.

INTRODUCTION

IN May and June 1959 Professor H. C. Barnett collected many thousands of sand-flies during studies on sand-fly fever and other viruses (Barnett & Suyemoto, 1961) and kept as samples 9,900 which he asked me to identify, together with specimens collected in the Keris area by Lieut. Col. M. I. Burney and Lieut. Col. J. E. Scanlon. Professor Barnett arranged with the Pakistan Medical Research Centre for me to make a survey from 13th May to 30th June, 1963, and I visited Lahore, Rawalpindi, Taxila, Peshawar, Saidu Sharif, Bahrein, Kalam, Abbottabad, Nathia Gali, Gilgit, Chilas, Skardu, Keris, Karachi and neighbouring areas. Mr. W. A. McDonald contributed sand-flies from Lahore, Gujrat and Mir Muhammad. All the specimens numbered 11,100, and I have also examined many in the British Museum collected by the late Brigadier J. A. Sinton during his pioneer studies of the Phlebotominae.

¹This investigation was supported in part by U.S. Public Health Service Research Grants TW-00142-06 and A1-05589-03 from the Division of General Medical Sciences and the National Institute of Allergy and Infectious Diseases, National Institutes of Health, respectively.

The work is based largely on collections made by Professor Herbert C. Barnett, now Director of the Institute of International Medicine, University of Maryland, Baltimore, U.S.A., and on a survey made by the author under the auspices of the Pakistan Medical Research Centre, Lahore.

West Pakistan (Text-fig. 1), including northern Kashmir, comprises the great alluvial plain of the Indus and its tributaries in Sind and West Punjab, the hills and plateaux south-west of Peshawar, and the high mountains and valleys of the north. The northern mountains radiate from the Pamirs and comprise parts of the Hindu Kush, Karakoram and Himalayan ranges.

South of the Himalayas the climate is tropical and is dominated by the rhythm of the monsoons, but the rainfall is low and much of the area is cold in winter. North of the Punjab there are intermittent wet days in summer, and forest begins at about 1400 metres. The Himalayas stand in the path of the monsoon, so that the Karakoram is part of the central Asian desert. In the Gilgit and Skardu areas the general arid conditions contrast with narrow valleys of streams fed by vast areas of melting snow. Weak depressions from the Mediterranean (Bharadwaj, 1961) cause light winter rains in the north and some of the Himalayan snowfall. The area is described in the Imperial Gazetteer of India (1907) and briefly by Schmid (1958). Prater (1965: 21) indicates the plant zones, and Mani (1962), Lorimer (1939) and Maraini (1961) describe the western Himalayas and the country around Gilgit and Skardu respectively.

METHODS

Collecting. Sand-flies resting in houses were usually collected with a suction catcher, and some were taken by Mr. McDonald around Mir Muhammad in routine pyrethrum-spray catches of mosquitoes and on cattle.

Most outdoor catches in 1963 were made with sticky traps. They consisted of pieces of paper about 10 × 16.5 cm. smeared with castor oil and supported by cleft sticks about 28 cm. long, and were placed before dusk near animal burrows, rock crevices and other likely places. Two hundred and fifty ml. of oil sufficed for about 100 traps. Five hundred and forty were set, on 25 nights, and yielded 419 flies (from 0 to 2.6 per trap per locality—average 0.8), whereas the maximum on a single trap in Iran in June, 1960 (Lewis *et al.*, 1961) was 132. The low numbers in Pakistan were probably due partly to the preceding cold winter and, near Karachi, to wind.

Some sand-flies were driven from termite hills with tobacco smoke and caught in a fine-mesh black net, and a few were taken in a Damasceno-type trap, but this is more suitable for forest country where it can be slung from trees.

Preservation. Many specimens were preserved dry in vials or cardboard boxes, with tissue paper or cotton-wool to prevent shaking. Others were stranded in plastic vials and wetted with a few drops of gum-chloral mounting medium.

Mounting. Dry specimens were put in tap water containing one per cent of domestic detergent (to wet them), which was heated to about 85° C. for four minutes to remove bubbles. Specimens were roughly sorted according to external characters, including size, colour and, in the case of male *Sergentomyia*, the shape of the abdomen. Most of the flies were mounted in gum-chloral medium composed of distilled water (20 ml.), gum acacia (16 gm.), chloral hydrate (140 gm.), glycerol (12.6 gm.) and acetic acid (6.3 gm.), beneath circular cover-glasses 1 cm. in diameter and 0.1 mm. thick. The mounts were allowed to dry partially for a few months, or kept over silica gel

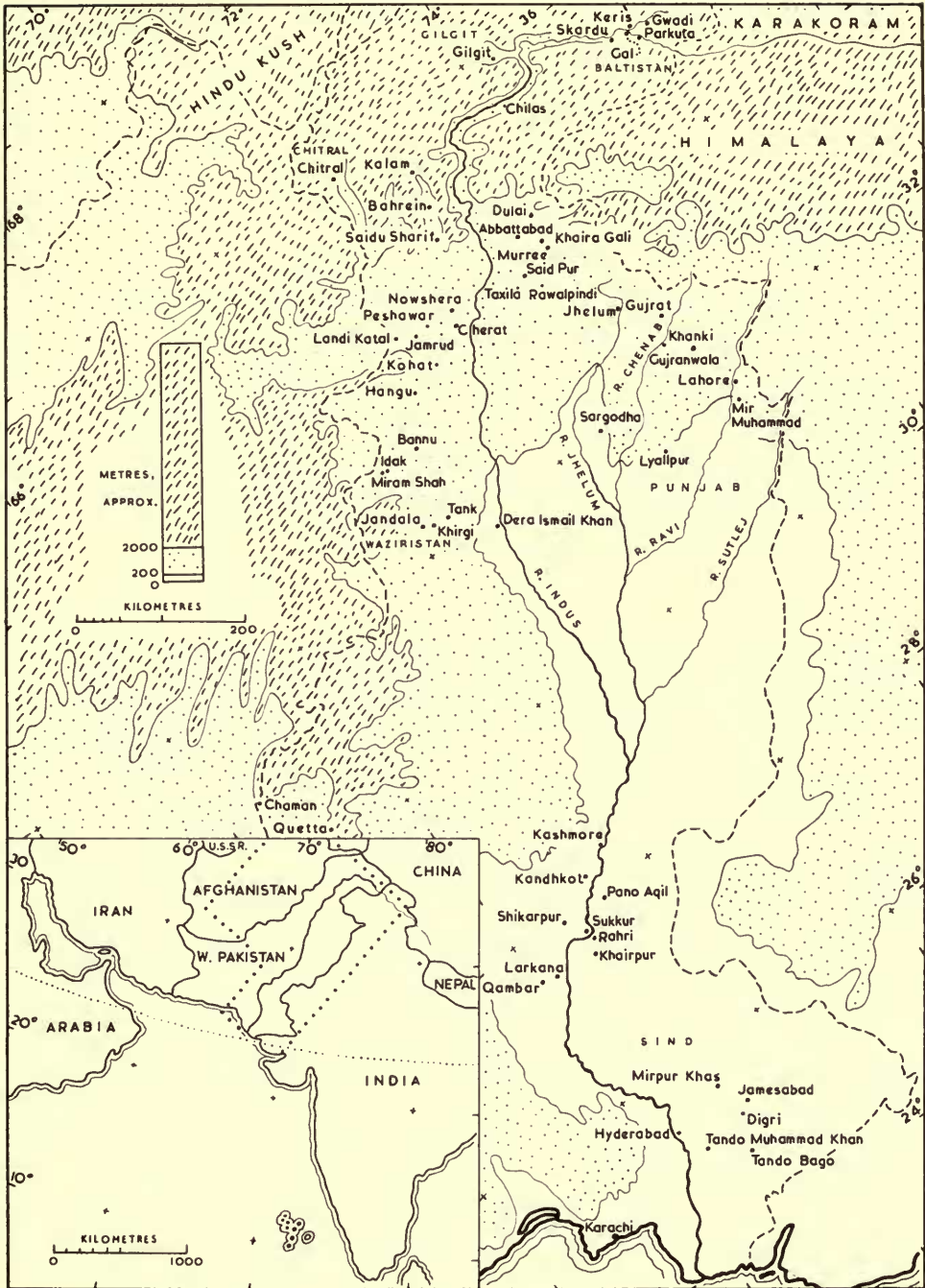


FIG. 1. Showing places mentioned in the text.

for a few days, and ringed with Euparal. An oven was not used because it involves the risk of over-drying or overheating. Three beads, each 1 mm. high, were attached with Euparal to each slide to protect the cover glasses, so that many slides could be stored in drawers without slots. In mounts of this kind the specimens remain soft and flexible, and suitable for reorientation of particular structures. The soft parts become invisible without being destroyed, as they are by caustic potash, so that a specimen keeps its shape and can even be sectioned to show the position and general structure of internal organs.

The cibarium and pharynx were examined *in situ* in ventral view. The spermathecal ducts of many previously mounted specimens were examined. For this purpose they were extracted by wetting, and mounted temporarily in an equal mixture of water and gum-choral to give a suitable refractive index. In the case of some very delicate species tergite 9 and sternite 8 were removed.

In damp climates where gum-chloral mounts may require too much attention fairly good results can be obtained by mounting in Euparal after dehydration in alcohol up to 95 per cent. Various methods of staining after maceration give a very clear picture of certain chitinous structures but they hide colour variation and the natural appearance of the insect as seen in freshly dissected flies.

CLASSIFICATION

The term sand-fly is used here for species of the tribe Phlebotomini, as defined by Fairchild (1955), other than *Hertigia* and *Warileya*. The classification of the sand-flies, the names of certain structures, and various taxonomic expressions are discussed by Kirk and Lewis (1951), Fairchild (1955), Theodor (1958), Quate (1964), Abonnenc & Minter (1965) and others. At present some authors place all sand-flies, of both Old and New Worlds, in one genus *Phlebotomus*, and others divide them into several genera. The system of Theodor (1948, 1958) is used here.

It is often hard to delimit species and subspecies of Phlebotominae. Cross-mating is difficult, the early stages of most species are unknown, and knowledge of distribution is limited by the need for special collecting methods. Furthermore, some characters are less precise than they seem. For instance, when the cibarial teeth are counted *in situ* in the normal way some lateral ones may be hidden. If the head is flattened the specimen is damaged and the lateral teeth may be found to merge imperceptibly into spicules and become impossible to count exactly. Measurements of the pharynx are often used, but it may be soft and flexible and its hind end is difficult to define. Various difficulties are illustrated by the recent treatment of the *Sergentomyia squamipleuris* complex by experienced entomologists. Theodor and Mesghali (1964) recognized four species and one subspecies, and Quate (1962a, 1964) placed all forms in one species. Fortunately, however, the small size of sand-flies and the practice of mounting them all on slides make it possible to amass large but compact collections for the study of variation and distribution, and the cibarial teeth provide useful characters for most Old World species.

Morphology. This is described in several standard works, and the following notes refer to particular features.

All the scales of at least one species have petioles (Nicoli, 1956), and many of the petioles in two species (*P. kandelakii* and *P. chinensis*) are distinctive.

There is some variation in the cibaria of *Phlebotomus* species, particularly the degree of visibility of the spicules or teeth, the hind margin of the ventral plate, and the chitinous arch.

The cibarial teeth of most species of *Sergentomyia* are clearly seen but those of *S. bailyi* are much less conspicuous than those of *P. colabaensis*.

The punctiform teeth, denticles, or nodules in front of the main cibarial teeth of *Sergentomyia* are often called vertical teeth but this term is seldom used here because they have also been termed horizontal teeth.

The posterior bulge (Text-fig. 9) in the dorsal wall of the cibarium of most American phlebotomines has been used by Theodor (1965a) as an important character for distinguishing them from Old World sand-flies. This seems to be a useful character but should be used with care because some Pakistan and other Old World species, particularly in the genus *Phlebotomus*, have a somewhat similar bulge (Text-figs. 3, 6, 8, 35, 84, 85 etc.). In most of these species the bulge is usually asymmetrical and evidently flexible, so that its appearance depends on method of preparation and angle of view. It tends to be less pronounced than in American species, and dome-shaped rather than mitre-shaped when seen in lateral view after removal of the sides of the head. In *Phlebotomus* there is an additional bulge in the region of the chitinous arch.

The length of the labrum was measured from the tip of the clypeus as seen in ventral view. This measurement, which is the approximate length of the structure, is often expressed as the length of the epipharynx, but this terminology is not correct because the epipharynx of insects is the ventral surface of both labrum and clypeus (Matsuda, 1965).

In male sand-flies the tip of the labrum is surmounted by a crest, as it may be called, which Grassi (1907) described as a *laminetta* in *P. papatasi*. Christophers *et al.* (1926) referred to it as a "peculiar flattish pad" in *P. argentipes*, which arises from the median chitination. They pointed out that near the base of the labrum this chitination lies between the two dilated parts of the lateral pieces, which form the basal bulge. Perfil'ev (1937) observed that the crest was rounded in a species of the subgenus *Sergentomyia* and terminally spiculated in *P. chinensis*. The crest often rises to a point which may be termed the summit in distinction from the terminal apex. In females the crest is lacking (Text-fig. 118) and would presumably prevent the labrum from piercing skin. There is a rather indefinite relation between types of crest and certain subgenera or groups of subgenera. In the genus *Phlebotomus* the summit hardly ever projects forward, and spicules are easy to see, partly owing to the size of the species; in subgenera *Phlebotomus* and *Paraphlebotomus* the summit is well defined. In the subgenus *Sergentomyia* the crest is rather similar but the spicules are usually inconspicuous. In most species of *Parrotomyia* the crest tapers and lacks a definite summit. In the two Pakistan species of *Grassomyia* and *Rondanomyia*, and in most *Sintonius*, the summit is rounded and projects forward. There are minor specific features in some cases, and certain species are characterized by other aspects of the labrum, the size and degree of

pubescence of the basal bulge, and the width of the lateral flanges (as seen in lateral view). It is interesting to note that unusual types of labrum occur in the rather unusual species *S. squamipleuris*, *S. pawlowskyi* and *S. bailyi*.

In the palpal ratio the first number indicates the combined lengths of segments 1 and 2, according to Quate's suggestion, and segment 5 is omitted in some species. Text-fig. 29 shows the junctions of the segments. Palpal segments were not always measured very accurately because this would have involved remounting or flattening many specimens.

Wing lengths were measured from the proximal end of the hairy basal bulge of the costa (Text-fig. 73). According to Quate's (1964) suggestion the terms R_2 , R_{2+3} , and R_1 tip are used instead of alpha, beta and delta.

In the males of most African species of *Sergentomyia*, other than subgenus *Sintonius*, the abdomen tapers toward the hind end. In a number of Pakistan species, however, tergite 6 is more or less enlarged so that the terminalia spring from a truncated end. This enlargement is often associated with absence of true hairs and the presence of large microtrichia.

The hair-like structures at the apex of the spermatheca are here termed gland ducts. As suggested by Quate, the terms "basistyle" and "dististyle" (discussed by Van Emden and Hennig, 1956, and Prasad and Grover, 1963) are used for "coxite" and "style", and "surstyle" for "lateral lobe".

The name "sand-fly". According to Murray (1888) this term was published for the first time by Walter (1748) who used it for insects which attacked members of Anson's expedition on the island of Santa Catarina, Brazil, in 1740. These were probably *Culicoides*, breeding in water but biting near sandy beaches. The name evidently did not originate from the Portuguese word for these flies or from the vernacular word discussed by Lane (1942) in his comments on the work of G. Marcgravius which was first published in 1648. The name "sand-fly" came to be used in several parts of the world, including India (Adams, 1867, p. 59; Annandale, 1910), for various small biting flies. It became adopted as the usual English word for phlebotomines in some of the dry parts of Pakistan, India and the Mediterranean area, probably because the dusty conditions made the name seem appropriate, man-biting midges and simuliids were generally scarce or absent, and the extensive researches on leishmaniasis in these areas focussed attention on the phlebotomines. In Iran they are called *pasheh khaki*, "earth-coloured mosquitoes", but the English name for these inconspicuous flies does not seem to be due to their colour.

KEYS TO THE SPECIES KNOWN FROM WEST PAKISTAN

The following keys are based partly on Theodor's (1958) keys to the Palaearctic species, and should be used with the knowledge that additional species may be found in West Pakistan (Table I).

KEY TO GENERA

Cibarium unarmed or with scattered spicules, without pigment patch. Hairs on hind ends of abdominal tergites 2-6 erect, their sockets as large as on 1. Dististyle with 4 or 5 spines. **PHLEBOTOMUS**

Cibarium with 1 or more rows of teeth (scarcely visible in *S. bailyi*), pigment patch usually present. Hairs on hind ends of abdominal tergites 2-6 recumbent, sockets much smaller than on 1, except in a few species which have a few erect hairs. Dististyle with 4 large spines and an accessory ventral seta **SERGENTOMYIA**

TABLE I. *Some Records of Species which May Occur in West Pakistan.*

Species	Distance from Pakistan, km.	Reference
<i>Phlebotomus</i>		
<i>bergeroti</i> Parrot	163	Theodor & Mesghali, 1964
<i>salehi</i> Mesghali, 1965	380	Mesghali, 1965
<i>jacusieli</i> Theodor	527	Mesghali, 1965
<i>mofidii</i> Theodor & Mesghali	740	Theodor & Mesghali, 1964
<i>mongolensis</i> Sinton	373	Dolmatova <i>et al.</i> , 1962
<i>eleanorae</i> Sinton	260	Sinton, 1931a
<i>eleanorae</i> Sinton	465	Mesghali, 1965
<i>newsteadi</i> Sinton	212	Sinton, 1926
<i>Sergentomyia</i>		
<i>sintoni</i> Pringle	315	Mesghali, 1965
<i>p. paulowskyi</i> Perfil'ev	515	Mesghali, 1965
<i>zeylanica</i> Annandale	212	Sinton, 1928b

KEY TO FEMALES OF *PHLEBOTOMUS*
(except *P. nuri*)

- 1 Pharyngeal teeth small and punctiform, in rows or curved groups 2
- Pharyngeal teeth large, spermathecae without long process 5
- 2 Spermathecae with 30-35 segments, very long. Median pharyngeal teeth larger than lateral ones **kandelakii burneyi** (p. 17)
- Spermathecae with 8-21 segments 3
- 3 Spermathecae nearly cylindrical, with 12-16 segments. **major** (p. 21)
- Spermathecae with about 18-21 segments, narrowing at one or both ends 4
- 4 Spermathecae with about 18 segments, narrowing towards duct and broad at other end. Hind part of pharynx with small anterior toothed scales and posterior small punctiform teeth **keshishiani** (p. 19)
- Spermathecae with about 21 segments, narrowing at both ends sp. A (p. 21)
- 5 Spermathecae incompletely segmented, with indistinct transverse striations **chinensis longiductus** (p. 21)
- Spermathecae segmented 6
- 6 Pharynx armed with finely toothed scales or a network of lines **papatasi** (p. 14)
- Pharynx armed partly or wholly with strong backwardly directed teeth or scales 7
- 7 Pharyngeal armature with an anterior median group of strong scales or spines, and some scales forming concentric lines 8
- Pharyngeal armature composed of large backwardly directed teeth 9
- 8 Spermathecae with terminal segment much larger than the rest, ducts about 3 times as long as spermathecae **argentipes** (p. 23)
- Spermathecal segments equal, ducts very long **colabaensis** (p. 24)
- 9 Antennal segment 3 short (0.12-0.16 mm.), 0.5-0.6 length of labrum **alexandri** (p. 15)
- Antennal segment 3 long (0.23-0.33 mm.), 0.7-1 length of labrum **sergenti** (p. 17)

KEY TO MALES OF *PHLEBOTOMUS*(except *P. sp. A*)

- 1 Basistyle with a hairy process near its base. Genital filaments short, 1.3-2.3 times length of pump 2
 - Basistyle without such process 5
- 2 Basistyle long (0.37-0.63 mm.); basal process small, with few hairs. Dististyle long and cylindrical with 5 spatulate spines, 3 of them terminal. Paramere with 2 long dorsal processes. Surstyles with terminal spines *papatasi* (p. 14)
 - Basistyle short (0.2-0.33 mm.); basal process large or very large with many hairs. Paramere simple without upper process, with flat elliptical upper surface 3
- 3 Basal process of basistyle very large and thick, with many hairs on its distal third *nuri* (p. 15)
 - Basal process of basistyle small and thin, with hairs only at the end 4
- 4 Antennal segment 3 short (0.12-0.16 mm.), 0.7-0.9 length of labrum. Genital pump short (0.12 mm.), with small basal plate *alexandri* (p. 15)
 - Antennal segment 3 long (0.25-0.34 mm.), 1-1.4 times length of labrum. Genital pump large (0.17-0.2 mm.), with broad basal plate or funnel *sergenti* (p. 17)
- 5 Dististyle with 4 long spines *colabaensis* (p. 24)
 - Dististyle with 5 long spines, 2 at the end and 3 in the middle. Genital filaments long, 3-11 times length of pump 6
- 6 Paramere with 2 ventral lobes; 2 long slender spines on each side of the aedeagus *argentipes* (p. 23)
 - Paramere without ventral lobes 7
- 7 Mid-ventral surface of aedeagus finely serrated, aedeagus tapering gradually to a point through which the genital filaments emerge *kandelakii burneyi* (p. 17)
 - Aedeagus smooth 8
- 8 Genital filaments 3-5 times length of pump *major* (p. 21)
 - Genital filaments 6-11 times length of pump 9
- 9 Aedeagus with subterminal spike or tooth *chinensis longiductus* (p. 21)
 - Aedeagus without subterminal spike, narrow *keshishiani* (p. 19)

KEY TO FEMALES OF *SERGENTOMYIA*

- 1 Spermathecae segmented, ducts long and narrow 2
 - Spermathecae not segmented but may be indistinctly striated, ducts not long and narrow 5
- 2 Cibarium with about 50 teeth or more *hospitii* (p. 43)
 - Cibarium with about 18 teeth or less 3
- 3 Cibarium with about 5 widely spaced teeth *christophersi* (p. 40)
 - Cibarium with about 12-15 teeth close together 4
- 4 Cibarium with 12-15 long equal pointed teeth in a straight line. Pharynx with thick walls and an abrupt constriction behind the bulge. 1-4 papillae on antennal segment 3, 1-2 on 4 *clydei* (p. 42)
 - Cibarium with 12 teeth, their points directed upward and usually hidden, outer teeth sloping toward centre. Pharynx thin-walled, narrowing gradually behind bulge. 1 papilla on antennal segments 3 and 4 *tiberiadis* (p. 44)
- 5 Spermathecae with rounded capsules and external spicules. Cibarium with 33-36 parallel teeth in a comb-like row convex posteriorly. Pharynx bulging posteriorly, with well-developed teeth. Antennal segment 3 with no ascoid, 1 ascoid on segments 4-15 *squamipleuris indica* (p. 34)
 - Spermathecae smooth 6
- 6 Spermathecae with capsules 7
 - Spermathecae tubular 15
- 7 Spermathecal capsules about twice as long as wide 8

— Spermathecal capsules nearly spherical	14
8 Spermathecal capsules narrow towards tip	9
— Spermathecal capsules nearly elliptical	10
9 Cibarial teeth scarcely visible	<i>baillyi</i> (p. 38)
— Cibarium with distinct teeth and lateral groups of denticles; pigment patch with postero-dorsal process	<i>montana</i> (p. 39)
10 Cibarium with 2 teeth	sp. B (p. 32)
— Cibarium with 10 or more teeth	11
11 Cibarium with notch in hind end of ventral plate, and 10–30 teeth in a row concave posteriorly	12
— Cibarium without notch in hind end of ventral plate; with about 45–50 nearly equal teeth in a comb-like row	<i>africana asiatica</i> (p. 28)
12 Cibarium with about 10–14 teeth, notch shallow	<i>shorttii</i> (p. 31)
— Cibarium with about 16–30 teeth; notch deep	13
13 Cibarium with about 16–18 teeth	<i>baghdadis</i> (p. 30)
— Cibarium with about 30 teeth	<i>babu</i> (p. 28)
14 Pharynx with well developed teeth	<i>palestinensis</i> (p. 34)
— Pharynx with transverse folds or irregular scales	<i>grekovi</i> (p. 32)
15 Spermathecae with transverse striations. Pharynx with almost invisible spicules	<i>pawlowskyi hodgsoni</i> (p. 37)
— Spermathecae smooth. Pharynx with numerous teeth	16
16 Pharynx funnel-shaped, 1.5–2 times as long as hind width	17
— Pharynx conical, 2.5–3 times as long as hind width	18
17 Posterior edge of pharynx sharply defined and deeply indented	<i>punjabensis</i> (p. 27)
— Posterior edge of pharynx ill-defined and not deeply indented	<i>theodori</i> (p. 27)
18 Cibarium with 4 very large lateral teeth on each side of small central ones, and well-developed vertical teeth	<i>dentata dentata</i> (p. 25)
— Cibarium usually with 5 lateral teeth, which are not as large as in <i>dentata</i> , vertical teeth small	<i>dentata arpaklensis</i> (p. 25)

KEY TO MALES OF *SERGENTOMYIA*

(except sp. B)

1 Genital filaments widened at tips. Cibarium with internal lateral projections in front of teeth. No ascoid on antennal segment 3. Parameres with rounded or truncated ends. Aedeagus much shorter than parameres and narrowing before tip like short sword. Abdominal tergite 6 narrower and longer than 5	<i>squamipleuris indica</i> (p. 34)
— Genital filaments not widened at tips	2
2 Aedeagus thick and finger-shaped	3
— Aedeagus conical and gradually tapering	5
3 Parameres hooked	<i>punjabensis</i> (p. 27)
— Parameres with rounded ends	4
4 Aedeagus bluntly pointed	<i>dentata dentata</i> (p. 25)
— Aedeagus with rounded end	<i>d. arpaklensis</i> (p. 23), <i>theodori</i> (p. 27)
5 Aedeagus with a sharp point	6
— Aedeagus with a blunt point	10
6 Pigment patch conspicuous and very well defined. Cibarium with about 34 teeth. Large species	<i>hospitii</i> (p. 43)
— Pigment patch inconspicuous. Cibarium with 30 teeth or fewer	7
7 Palpal formula 1, 2, 3, 4, 5. Aedeagus triangular, tapering uniformly from the base, long	<i>africana asiatica</i> (p. 28)
— Palpal formula 1, 2, 4, 3, 5. Aedeagus narrowing abruptly behind the base, very narrow apically	8

- 8 Cibarium with 8 or fewer widely spaced teeth **christophersi** (p. 40)
 — Cibarium with 12 or more teeth, close together or in groups 9
- 9 Cibarium with 20–22 small pointed teeth, most in groups of 2–4. Surstyles distinctly longer than parameres. Papilla formula 1–3/3, 1–2/4 **clydei** (p. 42)
 — Cibarium with 12–14 wide teeth. Surstyles only slightly longer than parameres. Papilla formula 1/4 **tiberiadis** (p. 44)
- 10 Paramere with a spine-bearing process on its lower side at the base of the neck. Genital filaments with marked transverse striations **pawlowskyi hodgsoni** (p. 37)
 — Paramere without such a process 11
- 11 Cibarium with a patch of teeth on each side of a central row **montana** (p. 39)
 — Cibarial teeth not differentiated thus 12
- 12 Cibarium with well developed teeth in a curve or a straight line 13
 — Cibarium with 1 or 2 rows of pointed teeth, often scarcely visible, in a posteriorly concave row 14
- 13 Cibarium with 8–12 teeth in a straight line **palestinensis** (p. 34)
 — Cibarium with 14–16 teeth in a posteriorly concave row **grekovi** (p. 32)
- 14 Cibarial teeth very indistinct; hind end of cibarium very broad; centre of hind end of ventral plate straight when visible; chitinous arch prominent. Abdominal tergite 6 much narrower than 5 **bailyi** (p. 38)
 — Cibarial teeth often indistinct; hind end of cibarium not very broad; centre of hind end of ventral plate concave; chitinous arch not prominent. Abdominal tergite 6 slightly narrower than 5 **babu** (p. 28), **baghdadis** (p. 30), **shorttii** (p. 31)

TAXONOMY AND DISTRIBUTION OF THE SPECIES

The references in the taxonomic citations have been selected from a large number which may be found in the papers of Sinton (1932, 1933*c, d*), Theodor (1948, 1958), Kirk & Lewis (1951), Quate (1964) and Theodor and Mesghali (1964), and in papers mentioned by them.

Descriptions of some species have been published by Theodor (1958), and many were figured by Sinton (1932, 1933*d*). Some descriptions given below refer to Pakistan forms of variable species, and some others are given here because existing descriptions are old or not readily available.

Some descriptions of cibaria and pharynges differ from those of Sinton because he removed them from the head, after maceration and staining.

The numbers of ascoids on antennal segments, and numbers of papillae on proximal segments (Parrot, 1953) are omitted unless they are unusual.

Hair sockets of females are shown in dorsal views of segment 3, and those of males in lateral views of the hind end of segments 5 and 6.

Certain of the structures of minor taxonomic importance, such as the furca, are omitted from descriptions for the sake of brevity.

In the sections on distribution, place names from various sources are omitted if they have been listed from earlier sources. Records from places which could not be certainly identified have been omitted, together with some records published before modern methods of identification came into use. Some localities are taken from notes deposited by Sinton in the British Museum.

Many specimens were taken in a group of localities and are recorded from the principal one, as follows. Gujrat: Mangowol. Mir Muhammad: Mianwali, Sadhana, Shahzada. Peshawar: Ahmad Khel, Badbher, Bahadur, Bazid Khel,

TABLE II. Percentages of Species of *Phlebotomus* (Males) and *Sergentomyia* (Females) in Certain Areas. Italics Indicate Actual Numbers. The Proportions of the Genera and Sexes are Largely Due to Selection After Capture.

Collections	Houses			Houses and sticky traps	Light traps			
	Area	Lahore	R'pindi	Peshawar	Keris	Lahore	R'pindi	Peshawar
<i>Phlebotomus</i>								
<i>papatasi</i>	84	40·1	92·1	—	—	—	—	2
<i>alexandri</i>	—	—	—	0·6	—	—	—	—
<i>nuri</i>	—	2·0	—	—	—	—	—	—
<i>sergenti</i>	16	51·1	7·9	39·0	—	1	—	—
<i>ka. burneyi</i>	—	—	—	9·8	—	—	—	—
<i>keshishiani</i>	—	1·6	—	1·2	—	—	—	—
<i>major</i>	—	2·7	—	—	—	—	—	—
sp. A	—	0·1	—	—	—	—	—	—
<i>c. longiductus</i>	—	2·2	—	49·4	—	—	—	—
<i>argentipes</i>	—	0·1	—	—	—	—	—	—
Males	94	853	5363	164	—	1	—	2
Total	159	1019	5712	189	1	1	—	4
<i>Sergentomyia</i>								
<i>d. arpaklensis</i>	—	0·4	2·2	2	—	—	—	3·1
<i>theodori</i>	—	0·4	4·5	—	—	0·3	—	12·1
<i>punjabensis</i>	28·9	1·5	2·2	—	—	0·3	0·3	0·1
<i>babu</i>	22·4	39·1	—	—	—	—	2·2	—
<i>baghdadis</i>	30·3	17·0	89·9	—	—	1·0	2·2	0·8
<i>shorttii</i>	—	0·4	—	—	—	—	—	—
sp. B	—	—	0·6	—	—	—	—	—
<i>palestinensis</i>	—	—	—	—	—	—	—	0·1
<i>sq. indica</i>	1·3	7·0	—	—	—	82·9	42·7	72·5
<i>paw. hodgsoni</i>	1·3	2·6	—	—	—	—	1·0	0·8
<i>bailyi</i>	—	25·1	—	—	—	0·3	10·4	0·1
<i>montana</i>	—	0·7	—	2	—	—	—	—
<i>christophersi</i>	15·8	—	—	—	—	—	—	—
<i>clydei</i>	—	0·4	—	—	—	15·4	40·7	10·4
<i>hospitii</i>	—	5·5	—	—	—	—	—	—
<i>tiberiadis</i>	—	—	0·6	—	—	—	—	—
Females	76	271	178	4	298	316	—	662
Total	309	1376	359	7	454	458	—	816

Shahb Khel, Sheikh Muhammadi. Rawalpindi: Bakra Mandi. The areas in Table II include the places mentioned and the following. Keris: Gol, Gwadi (or Guari), Parkuta. Lahore: Mir Muhammad. Peshawar: nearby villages. Rawalpindi: Said Pur, Taxila.

The locations of certain type specimens are abbreviated as follows. British

Museum (Natural History): "B.M. (N.H.)". Department of Parasitology, Hadassah-Hebrew University Medical School, Jerusalem: "Jerusalem".

PHLEBOTOMUS Rondani

Phlebotomus (Phlebotomus) papatasi (Scopoli)

(Text-figs. 2-4)

Bibio papatasi Scopoli, 1786, *Deliciae Florae et Faunae insubricae* 1: 55. Ticini.

Phlebotomus papatasi (Gmelin); Grassi, 1907; Newstead & Sinton, 1921: 104 [surstyles]; Sinton, 1925a: 468 [surstyles].

Phlebotomus papatasi (Scopoli); Sacca, 1950, *Rc. Ist. sup. Sanità* 13: 684 [early stages]; Quate, 1964; Schmidt & Schmidt, 1962, 1963.

The following notes on Pakistan specimens include particulars for comparison with specimens from other areas.

♀. Cibarium with a few scattered minute ventral teeth and some lateral spicules; hind margin of ventral plate easily seen; chitinous arch prominent; dorsal wall with 2 bulges. Labrum 0.35 (0.30-0.40) mm. long. Antennal segment 3 is 0.26 (0.24-0.30) mm. long, 1.04 (0.99-1.09) length of 4+5, 0.75 (0.67-0.86) length of labrum; ascoid 0.43 (0.39-0.53) length of segment 4. Palpal segment 3 longer than 4; average ratio 10:10.0:7.3:18.9. Wing length 2.25 (2.01-2.57) mm., width 0.61 (0.53-0.69) mm.; R_2 is 1.5 (1.3-1.6) times length of R_{2+3} ; R_1 apex is 0.3 (0.2-0.4) length of R_2 .

♂. Cibarium very like that of female. Labrum 0.25 (0.22-0.28) mm. long, crest 0.09 as high as length of labrum, sloping upward to summit, truncated or projecting very slightly forward, pubescent near apex. Antennal segment 3 is 0.30 (0.26-0.335) mm. long, 1.0 (0.9-1.1) times length of 4+5, 1.2 (1.0-1.3) times length of labrum; ascoid is 0.23 (0.20-0.25) length of segment 4. Palpal ratio 10:10.4:8.4:19.0. Wing length 2.14 (1.78-2.40) mm., width 0.52 (0.45-0.63) mm.; R_2 is 1.4 (1.2-1.5) times length of R_{2+3} ; R_1 apex is 0.30 (0.17-0.41) length of R_2 . Genital filament about 1.6 times pump length. Surstyles each with 2 terminal spines except in 1 fly with 2 and 3.

Comparison of the above figures with those of the extensive analysis of Egyptian specimens by Schmidt and Schmidt (1963) does not indicate any marked regional variation in this species. The Pakistan figures do show rather long ascoids and wings (easily measurable structures) in the males, but very similar results were obtained with 10 males taken in winter at Delgo and Saras in the northern Sudan: ascoid 0.25 (0.22-0.29) length of segment 4; wing length 2.20 (2.04-2.34) mm., width 0.56 (0.51-0.62) mm. The difference between Pakistan and Egyptian specimens may be due to individual variation and to seasonal or other local ecological conditions.

There are 6 spines on one dististyle of a male from Kashmore, 3 along the shaft instead of 2.

Specimens measured. 10 ♀ and 10 ♂ from the Rawalpindi area.

Distribution. Newstead & Sinton (1921): Bannu, Dera Ismail Khan (iii, iv, v, ix, x), Idak, Tank. Sinton (1924b): Kohat, Lahore, Miramshah, Nowshera, Quetta, Rawalpindi, Sinton (1927a): Jandola, Khirgi, Landi Kotal, Peshawar. Sinton (1932): scattered all over the plains of the Indo-Pakistan subcontinent,

more especially in hot dry areas ; has been found as far east as Calcutta and as far south as Madras City, but is most common in the north-west. Munir (1963) : Chilas, Gilgit. B.M. (N.H.) : Digri, Jhelum, Kandhkot, Kashmore, Larkana, Mirpur Khas, Shikarpur. Sinton's notes : Chaman, Hyderabad, Jamesabad, Jamrud, Karachi, Khairpur, Pano Aqil, Tando Bago. Present survey : Abbottabad, Mir Muhammad, Said Pur, Taxila.

***Phlebotomus (Paraphlebotomus) alexandri* Sinton**

(Text-fig. 5)

Phlebotomus sergenti var. *alexandri* Sinton, 1928b : 308.

In the one male taken in the present survey the cibarium is very like that of *P. papatasi* but the teeth are more delicate and the hind margin of the ventral plate is indefinite. The labral crest is obviously pubescent and rises rather abruptly to its rounded non-projecting summit. Antennal segment 3 is 0.154 mm. long, 0.66 length of labrum. The genital pump is 0.13 mm. long.

Distribution. Sinton (1928b) : Waziristan. Sinton (1932) : western frontier. B.M. (N.H.) : Kambhar [probably Qambar], north-west frontier. Sinton's notes : Dera Ismail Khan, Hyderabad, Kandhkot, Larkana, Shikarpur, Tank. Present survey : Parkuta. This species is widely distributed around the Mediterranean and is apparently always rare (Theodor & Mesghali, 1964), and the same is probably true of West Pakistan.

***Phlebotomus (Paraphlebotomus) nuri* sp. n.**

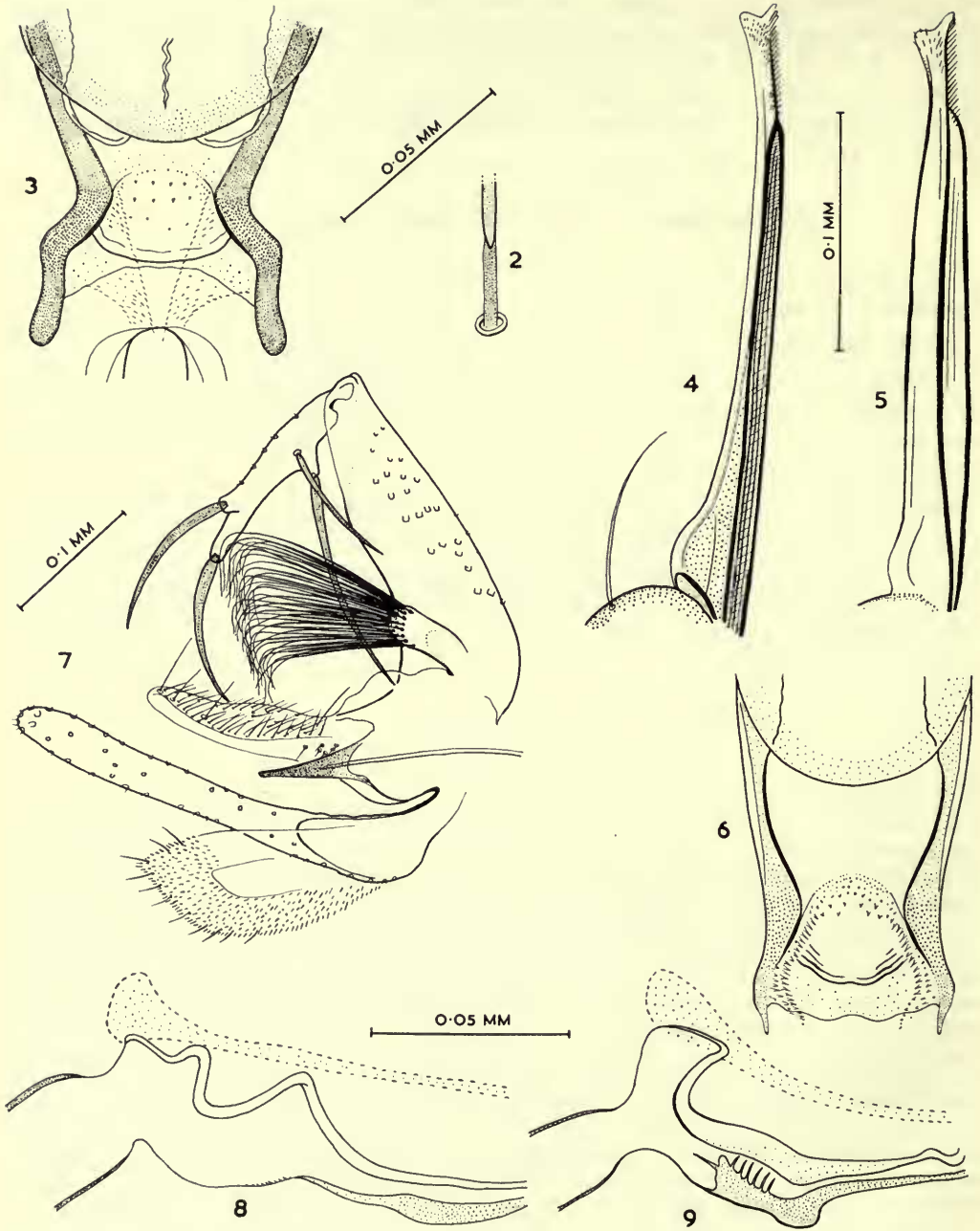
(Text-figs. 6, 7)

♀. Unknown.

♂. Cibarium with numerous delicate lateral spicules which merge into a group of about 10 small pointed scattered ventral denticles, and about 40 minute spicules in front of them ; chitinous arch well developed ; pigment patch absent ; dorsal wall of cibarium with posterior bulge. Pharynx armed with transverse scale-like ridges and posterior rows of minute denticles. Labrum 0.30 (0.28-0.34) mm. long, crest pubescent and non-projecting as in *P. sergenti*. Antennal segment 3 is 0.33 (0.31-0.37) mm. long, about 1.2 times length of 4+5, about 1.1 times length of labrum ; 2 ascoids on segments 3-15, that on 4 is about 0.25 length of segment ; a papilla on 3-5. Palpal ratio 10 : 10.0 : 6.8 : 20.2 ; segment 3 with inward bend at 0.7. Wing length 2.30 (2.08-2.52) mm., width 0.62 (0.56-0.69) mm. ; R_2 is 1.5 (1.3-1.7) times length of R_{2+3} ; R_1 apex is 0.2 (0.1-0.3) length of R_1 . Basistyle 0.30 (0.28-0.34) mm. long ; with basal process about 0.08 mm. long and 0.03 mm. wide, bearing on its distal third a thick brush of long downward-curving hairs, the most proximal ones being ventral. Dististyle 0.17 (0.16-0.19) mm. long, more than half length of basistyle and about 4 to 6 times as long as its own width ; with a thick terminal spine, another at 0.8, and a thick and a thin spine at 0.4. Paramere with flat elliptical upper surface. Aedeagus short and conical, with blunt end. Surstyle 0.35 (0.32-0.39) mm. long. Genital pump about 0.17 mm. long, filaments about 1.5 times this length.

Holotype ♂. WEST PAKISTAN : Said Pur, 21.v.1959 (*H. C. Barnett*), in B.M. (N.H.).

Paratypes : WEST PAKISTAN : Rawalpindi and Said Pur, 9 ♂, in B.M. (N.H.) ; Said Pur, 1 ♂, in U.S. National Museum ; 1 ♂ in Jerusalem.



FIGS. 2-9. *Phlebotomus papatasi*, 3, ♀, 2, 4, ♂. 2, base of hair from first coxa; 3, cibarium; 4, labrum. *P. alexandri*, ♂. 5, labrum. *P. nuri*, ♂. 6, cibarium; 7, terminalia. *P. sergenti*, ♀. 8, semidiagrammatic optical section of cibarium. *Lutzomyia panamensis* (Shannon) (American), ♀. 9, the same for comparison.

Distribution. Present survey : Rawalpindi and Said Pur.

This species has a longer dististyle than that of *P. caucasicus* and is related to *P. andrejevi* Shakirsjanova (discussed by Theodor & Mesghali, 1964) from which it differs in the relation of antennal segment 3 to 4+5, the relatively short palpal segment 4, the arrangement, length and curvature of hairs on the process of the basistyle, and the long narrow dististyle with a slightly different arrangement of spines.

Specimens examined. 11 ♂ from Rawalpindi and Said Pur (10 measured).

This species is named in honour of Lieut. Col. Nur Ahmad.

Phlebotomus (Paraphlebotomus) sergenti Parrot

(Text-fig. 8)

Phlebotomus sergenti Parrot, 1917, *Bull. Soc. Path. exot.* **10** : 564.

The cibarium of both sexes is very like that of *P. papatasi* but the teeth are smaller and less scattered. The labral crest of the male is like that of *P. alexandri*.

Distribution. Newstead & Sinton (1921) : Dera Ismail Khan. Sinton (1922) : Lahore. Sinton (1924b) : rare and localized ; very localized at Lahore ; Quetta. Sinton (1927a) : Chitral, Landi Kotal. Sinton (1929) : Sukkur. Sinton (1932) : in the Indo-Pakistan subcontinent it is apparently confined to the plains north-west of a line between Bombay and Simla, and it and *P. papatasi* are found under similar conditions. Sinton's notes : Cherat, Jhelum, Shikarpur, Tank. Present survey : Chilas, Gilgit, Gol, Gwadi, Keris, Mir Muhammad, Parkuta, Peshawar, Rawalpindi, Said Pur, Taxila.

Phlebotomus (Larrousius) kandelakii burneyi subsp. n.

(Text-figs. 10-14)

Phlebotomus kandelakii Shurenkova ; Barnett & Suyemoto, 1961 : 616 ; Nasir, 1964 : 26.

♀. The petioles of many of the scales are distinctive owing to their transparency in contrast to the rest of the scale. Cibarium without denticles, distinct chitinous arch, or a visible hind margin of the ventral plate ; dorsal wall with 2 folds. Pharyngeal armature occupying the hind 0.28 of the pharynx, anterior teeth scale-like and bearing spicules, the rest are small denticles. Labrum 0.28 (0.27-0.29) mm. long. Antennal segment 3 is 0.265 (0.24-0.30) mm. long, 1.2 (1.2-1.3) times length of 4+5, same length (0.8-1.0) as labrum ; 2 ascoids on segments 3-15, that on 4 being 0.35 (0.3-0.4) length of segment ; 1 papilla on segments 3-5. Palpal ratio about 10 : 8 : 7 : 2.1. Wing length 2.35 (2.29-2.46) mm., width 0.68 (0.63-0.72) mm. ; R_2 is 2.0 (1.8-2.3) times length of R_{2+3} ; R_1 apex is 0.3 (0.3-0.4) length of R_2 . Spermatheca narrow at ends and with long neck and about 30-35 segments which merge gradually into ill-defined rings on the duct ; duct wide and thin-walled at its hind end ; posterior edges of furca meeting at an acute angle.

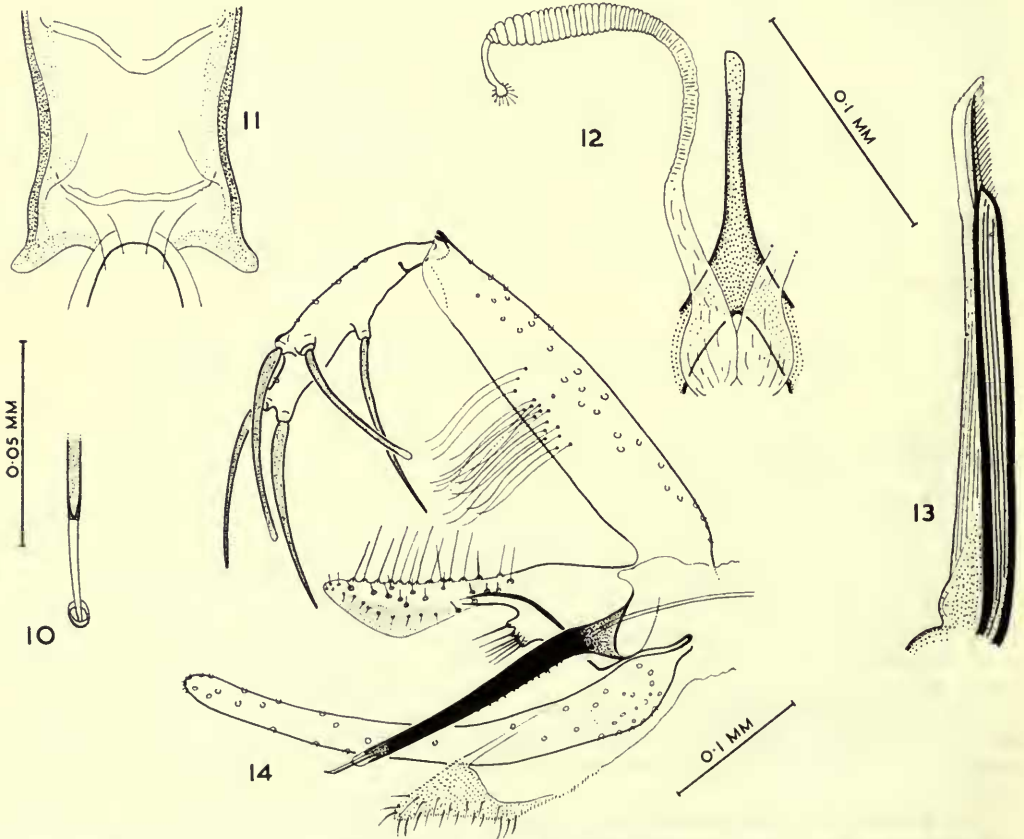
♂. Scale petioles and cibarium as in female. Pharynx with smaller armature. Labrum 0.22 (0.20-0.24) mm. long ; transparent part of crest short and low, with an ill-defined curved summit and a few distal spicules. Antennal segment 3 is 0.31 (0.26-0.33) mm. long, 1.1 times length of 4+5, 1.4 (1.3-1.5) times length of labrum ; ascoids paired on segments 3-7, single on

8-15, that on 4 being 0.2 (0.2-0.3) length of segment. Palpal ratio 10:8.5:8:21. Wing length 2.02 (1.81-2.07) mm., width 0.53 (0.45-0.57) mm.; R_2 is 1.8 (1.3-2.1) times length of R_{2+3} ; R_1 apex is 0.3 (0.2-0.4) length of R_2 . Basistyle about 0.31 mm. long, with about 20, not very long, ventral non-deciduous hairs. Dististyle about 0.16 mm. long, about half length of basistyle, with 2 terminal spines, 1 spine at 0.5, and 2 at 0.75. Paramere light brown, with a short sub-basal ventral process bearing about 7 spines, a narrow neck and, on the distal half, a grey nearly smooth ventral flange; depth of distal part about 0.32 of distance from its tip to tip of process (about 0.22 in *P. k. kandelakii*). Aedeagus long, with a blunt transparent tip and a row of very fine ventral teeth which are mainly on the basal half. Genital pump about 0.15 mm. long, filaments about 3.6 times as long. Surstyle about 0.34 mm. long.

Holotype ♂. WEST PAKISTAN: Gwadi, 25.vi.1959 (*M. I. Burney*), in B.M. (N.H.).

Paratypes: WEST PAKISTAN: Gwadi, Kalam, Keris and Parkuta, 6 ♀, 13 ♂ in B.M. (N.H.): Keris, 1 ♀, 3 ♂, in U. S. National Museum, Washington.

Distribution. Present survey: Gwadi, Kalam (2,070 metres), Keris (house in evening), Parkuta.



FIGS. 10-14. *Phlebotomus kandelakii burneyi*, 11, 12, ♀, 10, 13, 14, ♂. 10, base of hair from first coxa; 11, cibarium; 12, spermatheca; 13, labrum; 14, terminalia.

This form differs from *P. k. kandelakii* in the deeper distal part of the paramere. Further study is needed to show if slight differences in the pharyngeal armature, the ascoid distribution in the male, and the position of teeth on the aedeagus are significant. On the average, the labrum of *P. k. burneyi* is relatively short, palpal segment 5 is long, R_2 is relatively long in the female, and non-deciduous hairs of the style are more numerous than in *P. k. kandelakii*. The tip of the aedeagus resembles that of a male taken by Shurenkova at Tiflis in 1930.

Specimens measured. 6 ♀ and 10 ♂ from Gwadi and Keris.

This form is named in honour of Lieut. Col. M. I. Burney.

Phlebotomus (Larrousius) keshishiani Shurenkova

(Text-figs. 15-19)

Phlebotomus keshishiani Shurenkova, 1936, *Med. Parasit.* 5 : 922 ; Theodor, 1958 : 24 ; Theodor & Mesghali, 1964 : 291.

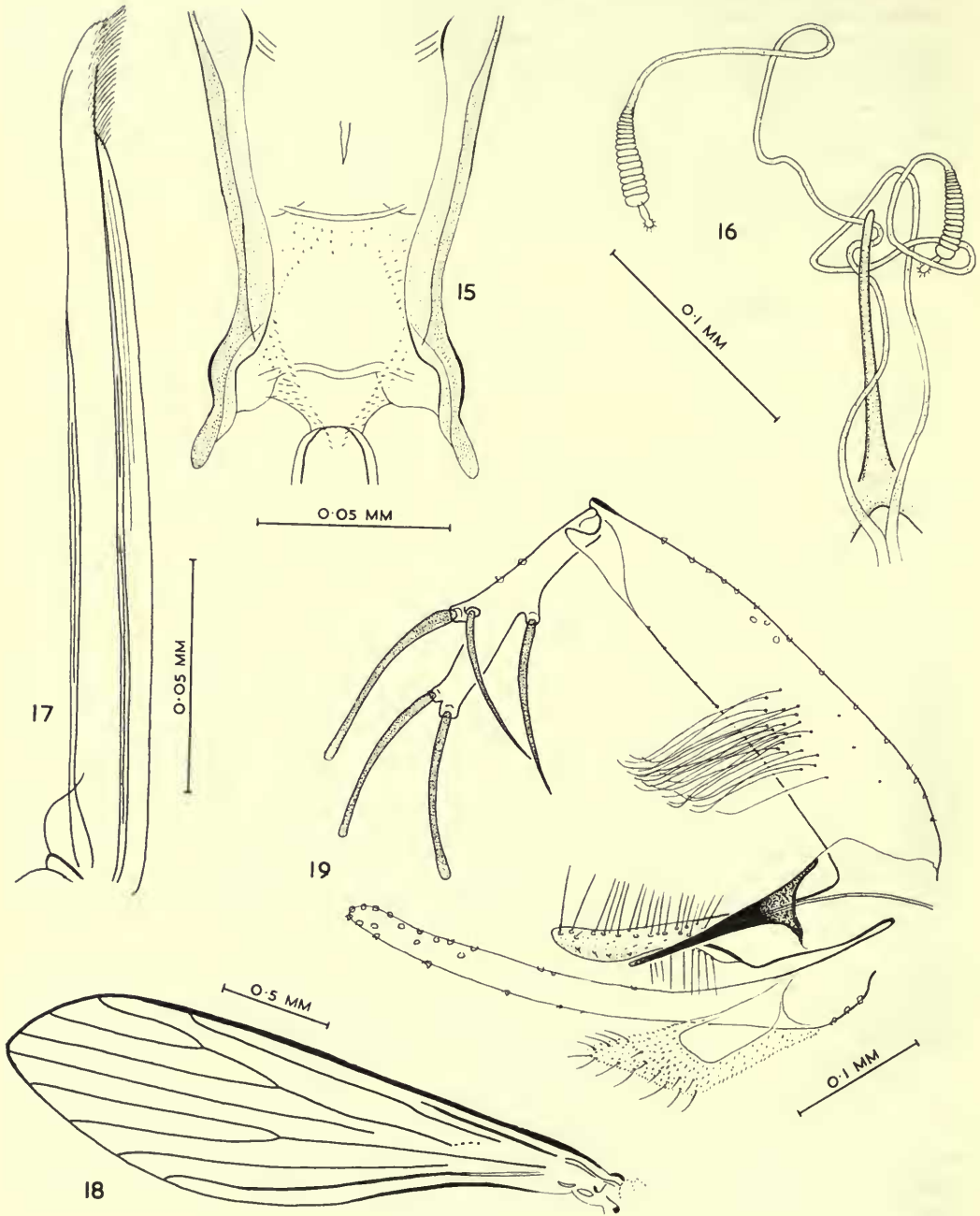
♀. A very large pale sand-fly. Cibarium with delicate lateral spicules which merge into a small ventral group of minute spicules ; chitinous arch absent ; ventral plate without definite hind margin ; 2 dorsal bulges present. Pharyngeal armature composed of anterior scales and posterior punctiform teeth. Labrum 0.38 mm. long. Antennal segment 3 is 0.34 mm. long, 1.3 times length of 4+5, 0.9 length of labrum ; ascoid 0.4 length of segment 4. Palpal ratio 10 : 8 : 7. Wing length 2.90 mm., width 0.85 mm. ; R_2 is 1.7 times length of R_{2+3} ; R_1 apex is 0.2 length of R_2 . Spermatheca with about 18 segments, conical, narrowing towards duct ; end process relatively short, about 3 times as long as wide.

♂. Cibarium very like that of female. Pharynx armed with punctiform teeth and a few scales in front of them. Labrum 0.34 (0.30-0.38) mm. long, crest with rounded non-projecting summit, terminal spicules, and a small basal bulge. Antennal segment 3 is 0.47 (0.40-0.57) mm. long, 1.3 (1.1-1.5) times length of 4+5, 1.4 (1.3-1.6) times length of labrum ; ascoids paired on 3-8, single on 9, that on 4 being 0.3 (0.3-0.4) length of the segment. Palpal ratio about 10 : 9 : 7 : 21. Wing with rather straight front margin, length 2.89 (2.42-3.29) mm., width 0.82 (0.70-0.97) mm. ; R_2 is 1.8 (1.4-2.2) times length of R_{2+3} ; R_1 apex is 0.2 (0.2-0.4) length of R_2 . Basistyle about 0.44 mm. long, with about 30 non-deciduous hairs. Dististyle about 0.22 mm. long, with 2 spines terminal, 2 at 0.7, and one at 0.5. Aedeagus conical with extremely narrow rounded tip. Genital pump about 0.16 mm. long, filaments about 8 times as long. Paramere with scattered ventral hairs beyond basal bulge, distal part slightly deeper than neck and grey along its lower surface. Surstyle about 0.43 mm. long.

Professor O. Theodor has identified this form by comparing it with Russian specimens. The above description tallies fairly well with his, but the Pakistan specimens are relatively large and have a different ascoid distribution, and the relative lengths of the palpal segments may indicate some variation. *P. keshishiani* differs from *P. smirnovi* Perfil'ev (1941) in having long spermathecal ducts and genital filaments, a large area of pharyngeal teeth, and other features. In Theodor's (1958) key to the males of Palaearctic *Phlebotomus*, *P. keshishiani* would run to couplet 16, differing from the other species indicated in the combination of blunt aedeagus, without lateral teeth, and long genital filaments.

Specimens examined, 1 ♀ and 20 ♂ (10 ♂ measured).

Distribution. Present survey : Gilgit, Parkuta, Rawalpindi, Said Pur.



FIGS. 15-19. *Phlebotomus keshishiani*, 15, 16, ♀, 17-19, ♂. 15, cibarium; 16, spermathecae; 17, labrum; 18, wing; 19, terminalia.

Phlebotomus (Larrousius) major major Annandale

(Text-fig. 20)

Phlebotomus major Annandale, 1910, *Rec. Ind. Mus.* 4: 46; Quate, 1962*b*; Theodor, 1958; Theodor & Mesghali, 1964: 281.

♂. No females were seen. Some particulars of males are as follows (10 from Said Pur measured). Cibarium with scarcely visible lateral spicules, 2 dorsal bulges, and no visible chitinous arch or hind margin to ventral plate. Labrum 0.28 (0.25–0.31) mm. long; crest with small basal bulge, slightly rounded non-projecting summit, and terminal spicules. Antennal segment 3 is 0.40 (0.35–0.48) mm. long, 1.2 (1.1–1.3) times length of 4+5, 1.5 (1.4–1.5) times length of labrum; ascoids paired on segments 3–8, single on 9, that on 3 being about 0.3 (0.3–0.4) length of segment. Palpal ratio about 10:9:7:18; segment 3 is 1.2 (1.0–1.3) times length of 2. Wing length 2.44 (2.23–2.81) mm., width 0.70 (0.63–0.86) mm.; R_2 is 1.9 (1.5–2.2) times length of R_{2+3} ; R_1 apex is 0.2 (0.2–0.3) length of R_1 . Basistyle about 0.38 mm. long. Dististyle about 0.19 mm. long. Genital pump about 0.15 mm. long, filaments some 4.3 times this length. Surstyle about 0.38 mm. long.

The relative lengths of palpal segments 2 and 3 suggest that the West Pakistan form has some affinity to *P. m. syriacus* Adler and Theodor, but it is treated as *P. m. major* in view of the degree of variation. *P. m. major* and *P. chinensis* vary in colour (Sinton, 1928*b*).

Type. ♂ lectotype, Naini Tal, India; in Zoological Survey of India (Quate, 1962*b*).

Distribution. Sinton (1932): it seems to be essentially a hill species in the Indo-Pakistan subcontinent where it occurs in areas some 1,500 to 2,100 metres up where there is marked rainfall in summer, apparently existing all along the Himalayan foothills. Present survey: Abbottabad, Rawalpindi, Said Pur.

Phlebotomus (Larrousius) sp. A

(Text-figs. 21, 22)

♀. Cibarium with rows of lateral spicules but no ventral ones, chitinous arch absent, ventral plate without definite hind margin, 2 dorsal bulges present. Pharynx very like that of *P. m. major*. Labrum 0.43 mm. long. Antennae, palps and wings missing. Spermatheca narrow at each end, with about 21 segments and a rather long thick-walled neck which is very narrow where it joins the terminal segment; ducts very long and narrow.

The one available specimen was taken in a house collection at Said Pur on 21.v.1959 (*H. C. Barnett*) together with a male of *P. m. major*, but it does not seem to belong to that species.

Phlebotomus (Adlerius) chinensis longiductus Parrot

(Text-figs. 23–33)

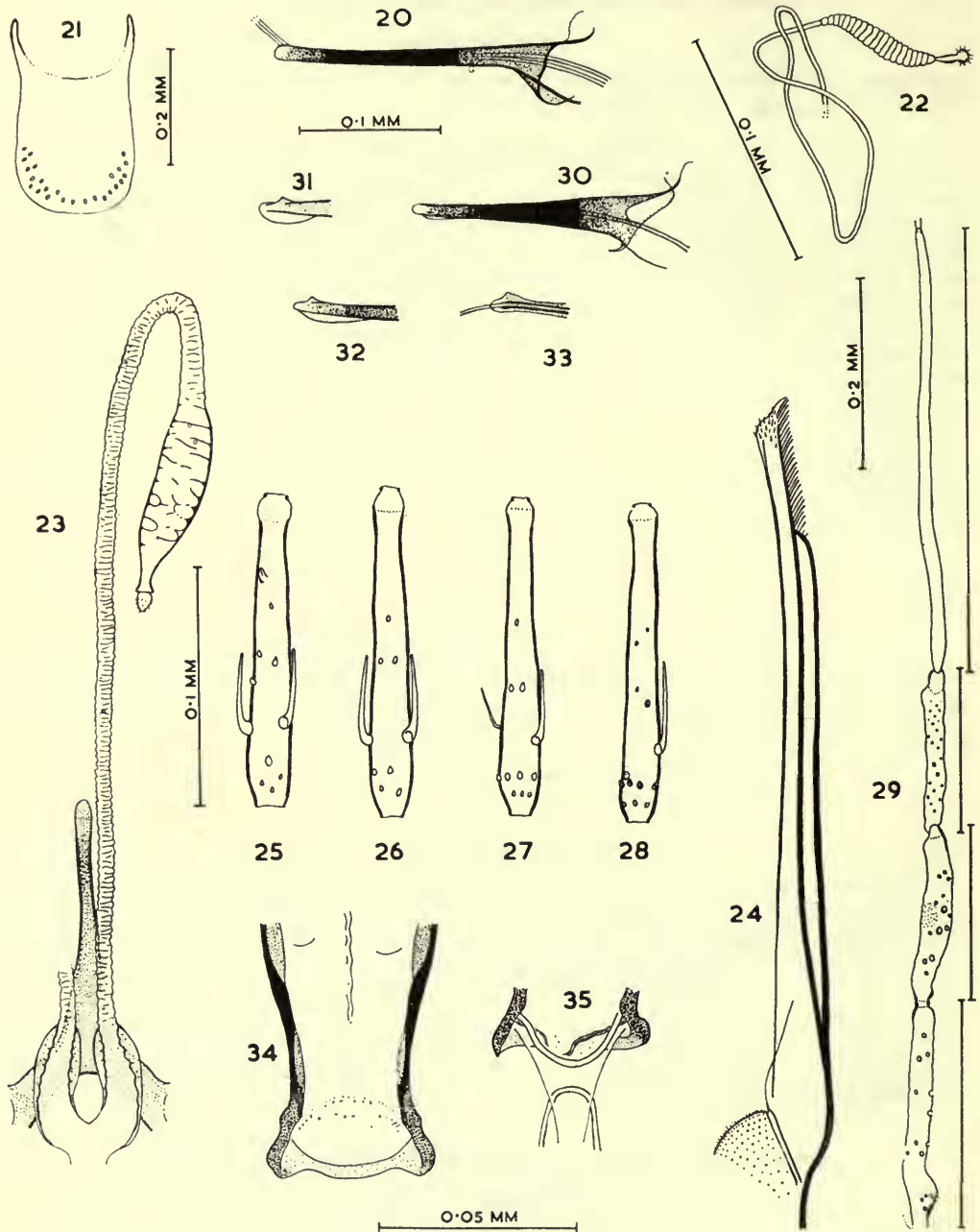
Phlebotomus chinensis; Sinton, 1928*b*: 306, [in part]; Adler & Theodor, 1929, [in part].

Phlebotomus major var. *longiductus* Parrot, 1928, *Archs Inst. Pasteur Algér.* 6: 29.

Phlebotomus chinensis var. *longiductus*; Theodor, 1948: 107; Theodor & Mesghali, 1964: 293.

Phlebotomus chinensis hindustanicus Theodor, 1958: 29, **syn. n.**

Phlebotomus chinensis longiductus; Theodor, 1958: 29.



FIGS. 20-35. *Phlebotomus major*, ♂. 20, aedeagus. *P. sp. A*, ♀. 21, abdominal sternite 2; 22, spermatheca. *P. chinensis longiductus*, 23, ♀, 24-33, ♂. 23, spermatheca; 24, labrum; 25-28, antennal segments 3-6; 29, palp; 30-33, aedeagus and tip from various angles. *P. argentipes*, ♂. 34, 35, cibarium.

♀. Petioles of many scales pale, as in *P. k. burneyi*, but this feature is less marked owing to the pallor of the shafts of the scales. The insect is very pale. Cibarium with scarcely visible lateral internal spicules, a short internal flange on each side, and 2 bulges in the dorsal wall; without a chitinous arch or a visible hind border to the ventral plate. Pharyngeal teeth occupying a third of the length of the pharynx, anterior ones forming a median group, posterior ones very broad and scale-like. Labrum 0.37 (0.32-0.39) mm. long. Antennal segment 3 is 0.32 (0.27-0.35) mm. long, 1.3 (1.2-1.4) times length of 4+5, 0.9 (0.8-1.0) length of labrum; ascoid on 4 is 0.4 (0.3-0.4) length of segment. Average palpal ratio 10 : 7.4 : 6.2 : 16.9. Wing length 2.54 (2.23-2.72) mm., width 0.74 (0.65-0.80) mm.; R_2 is 1.8 (1.4-2.0) times length of R_{2+3} ; R_1 apex is 0.2 (0.2-0.3) length of R_2 . Spermatheca narrow at each end, particularly toward the "head", with ill-defined compartments of different sizes, some of them packed together like cells; ducts long and wrinkled, each with a short posterior thick-walled section which joins the other duct at the outlet.

♂. Cibarium much like that of female. Pharynx with smaller armature. Labrum 0.27 (0.24-0.30) mm. long with very small basal bulge and a shallow crest with rounded summit and terminal spicules. Antennal segment 3 is 0.34 (0.28-0.39) mm. long, 1.2 (1.1-1.3) times length of 4+5, 1.3 (1.1-1.4) times length of labrum; ascoids paired on segments 3-5 and single on 6, except in one fly with an ascoid and a vestige of one on 6; ascoid on 4 is 0.3 (0.2-0.3) length of segment. Average palpal ratio is 10 : 8.0 : 7.0 : 19.2. Wing length 2.27 (2.01-2.54) mm., width 0.63 (0.54-0.77) mm.; R_2 is 1.8 (1.6-2.0) times length of R_{2+3} ; R_1 apex is 0.2 (0.1-0.3) length of R_2 . Basistyle about 0.38 mm. long, with a not very dense patch of about 60 non-deciduous hairs. Dististyle about 0.20 mm. long, 2 of spines terminal, one at 0.5, and 2 at about 0.6. Paramere very like that of *P. major*. Each plate of aedeagus tapering to a rounded tip, with a lateral subapical tooth and a transparent subterminal flange extending downward and slightly inward. In lateral view the tooth is scarcely visible, but slight changes in orientation can make it conspicuous and sometimes appear to be dorsal (in some descriptions of *P. chinensis* it is stated to be ventral); this tooth is 0.016 (0.015-0.018) mm. from the tip, and 0.015 (0.014-0.020) in 10 flies from Said Pur. Genital pump 0.13 (0.12-0.15) mm. long. filaments about 8.9 times this length. Surstyle about 0.41 mm. long.

Theodor (1958) pointed out that the form *hindustanicus* differed from *P. c. longiductus* in the position of the subterminal tooth of the aedeagus and that, when more specimens were available from the area between Turkestan and north-west India, the two forms might possibly be found to be the same. *P. chinensis* from West Pakistan proves to be intermediate in this respect, and form *hindustanicus* is therefore treated here as a synonym of *P. c. longiductus*. In Pakistan specimens antennal segment 3 is shorter than in those from India described by Theodor, and the ascoid distribution differs from that in Turkestan and India.

Specimens measured. 6 ♀ from Gol, Gwadi, Keris and Parkuta; 10 ♂ from Gol.

Distribution. Sinton (1932): similar, in the Indo-Pakistan subcontinent, to that of *P. major*. Mitra (1959) and Jacob and Kalra (1951): Punch (Kashmir). Nasir (1964): Gilgit. Present survey: Gol, Gwadi, Keris, Parkuta, Said Pur.

Phlebotomus (Euphlebotomus) argentipes Annandale & Brunetti

(Text-figs. 34, 35)

Phlebotomus argentipes Annandale & Brunetti, 1908, *Rec. Indian Mus.* 2 : 101; Sinton, 1925c; Christophers, Shortt & Barraud, 1926; Theodor, 1948 : 108; Keilin & Tate, 1937, *Para-*

sitology 29: 254 [larva]; Quate, 1962a: 254; 1962b; Quate & Fairchild, 1961, *Pacif. Insects* 3: 211.

Phlebotomus argentipes var. *glaucus* Mitra & Roy, 1953b, **syn. n.**

♂. The following are some particulars of West Pakistan specimens. Cibarium with a few small punctiform teeth, the anterior ones in a row; chitinous arch not visible; hind margin of ventral plate scarcely visible; 2 variable dorsal bulges present; sides very dark. Labrum 0.20 (0.19–0.21) mm. long, with small basal bulge; crest with low rounded non-projecting pubescent summit. Antennal segment 3 is 0.24 (0.22–0.25) mm. long, 1.1 (1.1–1.2) times length of 4+5, 1.2 (1.1–1.3) times length of labrum; ascoids paired on segments 3–10, single on 11–15, that on 4 being 0.4 (0.4–0.5) length of segment; papilla on 3 and 4. Average palpal ratio 10:9.0:4.8:13.8. Most of mesonotum and scutellum dark brown, pleura pale. Wing length 1.99 (1.98–2.02) mm., width 0.59 (0.55–0.62) mm.; R_2 is 1.8 (1.6–2.1) times length of R_{2+3} ; R_1 apex is 0.1 length of R_2 . Basistyle about 0.27 mm. long. Dististyle about 0.18 mm. long. Genital pump dark brown, 0.15 mm. long, filament about 2.3 times this length.

P. a. var. *glaucus* appears, from its description, to be a minor variant of this species.

Specimens measured. 6 ♂.

Type. ♂ lectotype, Calcutta, India; Zoological Survey of India (Quate, 1962b).

Distribution. Nasir (1964): Lahore. Present survey (♂): Mir Muhammad (10.iv.63, *W. A. McDonald*, 1 in house), Shahzada (May, 1963, *W. A. M.*, 3 on cattle), Taxila (29.v.59, *H. C. Barnett*, 1 in house).

Phlebotomus (Anaphlebotomus) colabaensis Young & Chalam

(Text-figs. 36, 37)

Phlebotomus colabaensis Young & Chalam, 1927, *Indian J. med. Res.* 14: 859; Sinton, 1932: 59; 1933c: 226; 1933d: 418; Theodor, 1958: 108.

♀. The following are some features of the one available specimen. Cibarium with no teeth in middle line, but an irregular row of about 5 spiculated teeth with broad delicate bases on each side; small spicules in front of these teeth; chitinous arch brown and well defined; ventral plate with visible hind margin; dorsal wall with 2 bulges. Labrum 0.26 mm. long. Antennal segment 3 is 0.28 mm. long, 1.1 times length of 4+5, 1.1 times length of labrum; ascoids paired on segments 3–15, that on 4 being 0.55 length of segment; papilla on segments 3–5. Palpal ratio 10:9.5: . . . Thorax pale grey. Wing length 1.96 mm., width 0.56 mm.; R_2 is 1.2 times length of R_{2+3} ; R_1 apex is 0.4 length of R_2 . Spermatheca with about 20 narrow segments which merge imperceptibly into wrinkles of the duct, terminal segment small and head oblong; ducts about 10 times length of spermathecae, uniting in short thick-walled common duct.

This may be a new species but is provisionally classed as *P. colabaensis* in the absence of a male. Sinton stated that the spermathecal ducts were four times as long as the spermathecae but the variation may be due to different methods of mounting.

Distribution. Sinton (1932): India (the small peninsula of Colaba at Bombay, and Vishakhapatnam). Present survey: Lahore, sticky trap in Davipur orchard, 16.v.1963 (*D. J. Lewis*).

SERGENTOMYIA Franca & Parrot*Sergentomyia (Sergentomyia) dentata dentata* (Sinton)

Phlebotomus dentatus Sinton, 1933a : 869 ; 1933c : 227 ; 1933d : 421.

Sergentomyia dentata (Sinton) ; Theodor, 1958 [in part] ; Theodor & Mesghali, 1964 : 293.

♀. Cibarium with 4 very large pointed teeth on each side and 6 small central ones, and a patch of small vertical teeth on each side ; chitinous arch present. Pharynx about 1.4 times as long as hind width, its armature comprising numerous long slender anterior teeth and a narrow group of small posterior teeth. Antennae missing. Palpal formula apparently 1-2-3-4-5 ; ratio 10 : 11 : 9 : 16. Wing length 1.68 mm., width 0.31 mm. ; R_2 0.6 length of R_{2+3} ; R_1 apex about 0.4 of R_2 . Spermathecae tubular with wide ducts.

♂. Cibarium with about 15 large pointed teeth in a row which is markedly concave backwards. Pharynx with several rows of pointed teeth, about 6 in each anterior row and about 3 in each posterior one. Antennae and wings missing. Dististyle with 4 apical spines, and seta at 0.8. Aedeagus finger-shaped and almost straight, with bluntly pointed end ; parameres blunt ; genital pump not visible.

This description is based on Sinton's. More specimens are needed for study.

LECTOTYPE ♀. WEST PAKISTAN : " Quetta co-type ♀ 1 ", in B.M. (N.H.), by present designation.

Paralectotypes : ♀ from Quetta labelled " co-type ", ♂ from Quetta labelled " type ", in B.M. (N.H.), by present designation.

Distribution. Sinton (1933a), Quetta.

Sergentomyia (Sergentomyia) dentata arpaklensis (Perfil'ev)

(Text-figs. 38, 39)

Phlebotomus minutus ; Sinton, 1932 : 61 [in part] ; 1933d : 42 [in part].

Phlebotomus minutus var. *arpaklensis* Perfil'ev, 1933, *Zool. Anz.* **101** : 226 ; Adler, 1946, *Bull. ent. Res.* **36** : 506.

Sergentomyia dentata var. *mediensis* Pringle, 1953, *Bull. ent. Res.* **43** : 714. Synonymy after Theodor & Mesghali, 1964.

Sergentomyia dentata : Theodor, 1958 [in part] ; Lewis, Mesghali & Djanbakhsh, 1961 [in part].

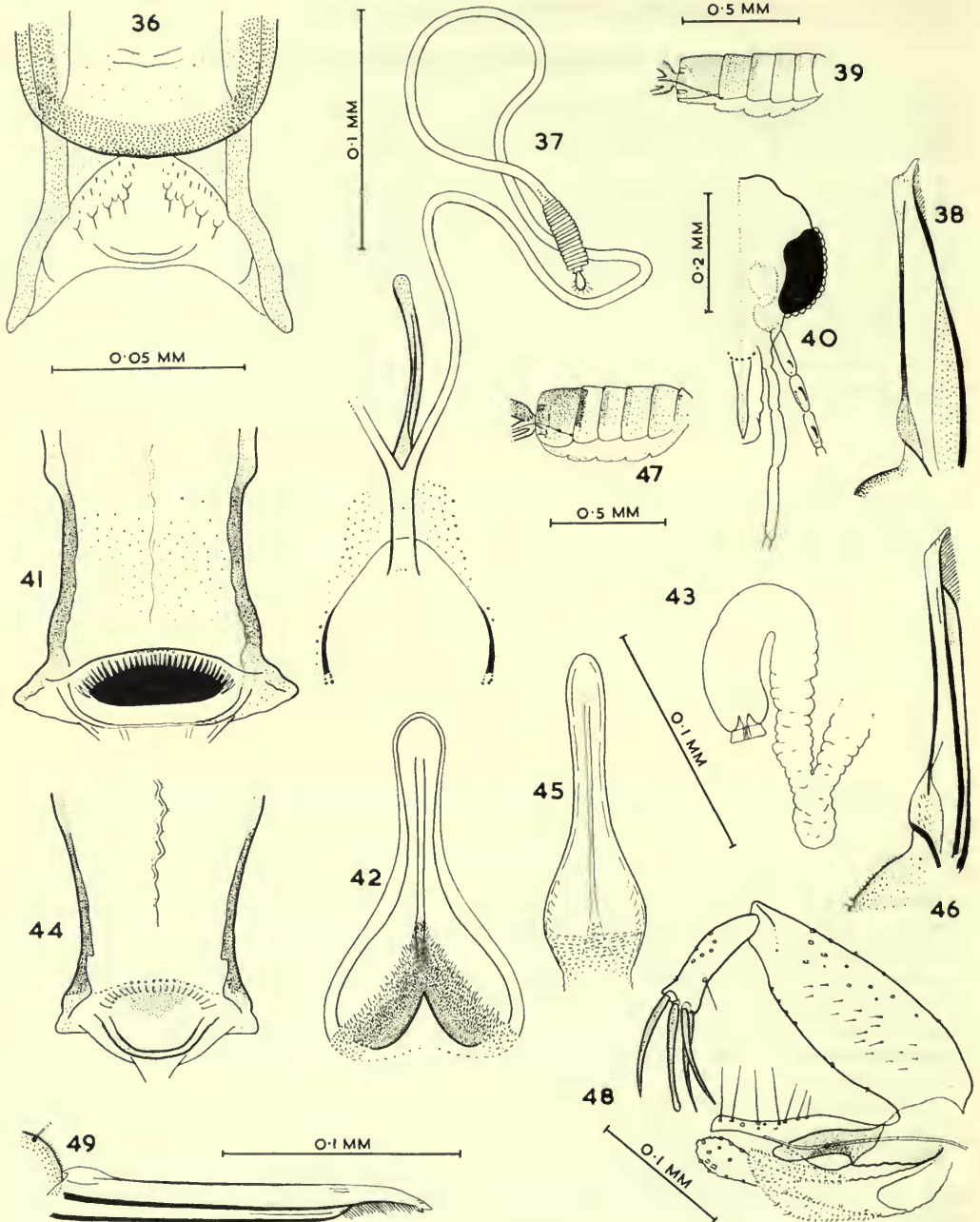
Sergentomyia dentata arpaklensis (Perfil'ev) ; Theodor & Mesghali, 1964.

The labral crest of the male is truncated, and in the male of this form or *S. theodori* abdominal tergite 6 is large.

Variation in *S. d. arpaklensis* is mentioned in the section on *S. theodori*. A related form in Sinkiang has been described as *P. minutus* var. *sinkiangensis* by Ting & Ho (1962).

Types. 12 syntypes, from the Kara-Kala area, Turkmeniya ; in the Russian Academy of Military Medicine.

Distribution. Present survey : Gwadi, Landi Kotal, Peshawar, Rawalpindi.



FIGS. 36-49. *Phlebotomus colabaensis*, ♀. 36, cibarium; 37, spermatheca. *Sergentomyia dentata* or *theodori*, ♂. 38, labrum; 39, abdomen. *S. punjabensis*, 40-43, ♀, 44-48, ♂. 40, head; 41, cibarium; 42, pharynx; 43, spermatheca; 44, cibarium; 45, pharynx; 46, labrum; 47, abdomen; 48, terminalia. *S. africana africana* (Ghana), ♂. 49, labrum.

Sergentomyia (Sergentomyia) theodori (Parrot)

Phlebotomus minutus: Adler & Theodor, 1926, *Bull. ent. Res.* **16**: 403; Sinton, 1932: 61, 73 [in part]; 1933*d*: 421, 422 [in part].

Phlebotomus theodori Parrot, 1942, *Archs Inst. Pasteur Algér.* **20**: 332.

Sergentomyia theodori (Parrot); Theodor, 1958; Lewis, Mesghali & Djanbakhsh, 1961; Theodor & Mesghali, 1964.

Some features of 10 ♀ from the Peshawar area are as follows. Labrum 0.15 (0.14–0.16) mm. long. Antennal segment 3 is 0.11 (0.10–0.11) mm. long, shorter than 4+5, 0.7 (0.7–0.9) length of labrum; ascoid about 0.4 length of segment 4. Palpal formula 1–2–4–3–5 or 1–2–(3–4)–5; ratio about 10:12:11; Newstead spines on 3 conspicuous. Wing length 1.50 (1.43–1.57) mm., width 0.30 (0.27–0.32) mm.; R_2 is 0.6 (0.4–0.8) length of R_{2+3} ; R_1 apex is –0.2 to +0.3 length of R_2 .

The character given by Theodor and Mesghali for separating females of *arpaklensis* and *theodori*, length of pharynx divided by its hind width, is very variable in Pakistan specimens, as it is in *S. punjabensis*. I am treating them here as species, however, because the specimens examined were few and from a limited area. The numbers of each form were estimated by regarding as *theodori* all females in which the above-mentioned fraction was 2.25 or less.

The labral crest of the male is truncated.

Distribution. B. M. (N.H.): Dera Ismail Khan, Kashmore, Larkana. Nasir (1958): Peshawar. Present survey: Landi Kotal, Rawalpindi.

Sergentomyia (Sergentomyia) punjabensis (Sinton)

(Text-figs. 40–48)

Phlebotomus minutus var. *antennatus*; Sinton, 1932: 61, 73.

Phlebotomus antennatus; Sinton, 1933*d*: 421; Qutubuddin, 1952: 79.

Phlebotomus punjabensis Sinton, 1933*d*: 421.

Sergentomyia punjabensis (Sinton); Theodor, 1948: 109; Qutubuddin, 1951: 36.

Phlebotomus antennatus var. *deccanensis* Qutubuddin, 1952: 79, **syn. n.**

♀. Cibarium with about 30 nearly uniform teeth on a posteriorly concave line, the outer ones visibly pointed; about 10 small punctiform teeth present; pigment patch broad, short and very dark; chitinous arch absent; lateral walls of narrow part of cibarium dark, with irregular inward surfaces. Pharynx 1.3–1.8 times as long as hind width, with sharply defined deeply notched posterior outline. Labrum 0.14 (0.13–0.15) mm. long. Antennal segment 3 is 0.09 (0.08–0.09) mm. long, shorter than 4+5, 0.6 (0.6–0.7) length of labrum; ascoid about 0.4 length of segment 4. Palpal formula 1–2–(3–4)–5 or 1–2–3–4–5; ratio about 10:12:13. Wing length 1.40 (1.21–1.50) mm., width 0.31 (0.28–0.33) mm.; R_2 0.6 (0.4–0.9) length of R_{2+3} ; R_1 apex 0.2 (0.1–0.4) length of R_2 . Spermathecae tubular with delicate ducts.

♂. Cibarium with about 20 nearly equal pointed teeth, which appear blunt in their normal position, and a few small punctiform teeth; pigment patch variable, usually short, broad and rather pale; chitinous arch absent. Pharynx with faint scaly sculpturing. Labrum 0.13 (0.12–0.14) mm. long, with some spicules on its basal bulge, and a pubescent truncated crest. Antennal segment 3 is 0.10 (0.09–0.11) mm. long, shorter than 4+5, 0.8 (0.7–0.8) length of labrum; ascoid about 0.3 length of segment 4. Wing length 1.35 (1.28–1.47) mm., width 0.27 (0.25–0.29) mm. Abdominal tergite 6 very large. Dististyle with 4 apical spines, and seta at

about 0.7. Aedeagus thick and curved, with rounded end ; genital filaments about 3.5 times pump length ; paramere with beak-like apex.

Specimens examined. Many from Dera Ismail Khan, Lahore, Peshawar and Rawalpindi areas, 10 ♀ and 10 ♂ measured.

Form *deccanensis* appears to be a synonym, because the pharynx of the female is like that of West Pakistan specimens, the greater length of antennal segment 3 is largely due to differences in body size, and the relative length of the dististyle is within the range of variation seen in West Pakistan.

Distribution. Qutubuddin (1951) : Kohat area. B.M. (N.H.) : Dera Ismail Khan, Jhelum, Khanki, Lahore, Peshawar. Present survey : Mangowol, Said Pur Shahzada.

Sergentomyia (Parrotomyia) africana asiatica (Theodor)

Phlebotomus africanus ; Sinton, 1932 : 61, 71 [Sind] ; 1933*d* : 422.

Phlebotomus africanus var. *asiaticus* Theodor, 1933, *Bull. ent. Res.* **24** : 541 [Israel] ; 1952, *Istanb. Univ. Fen Fak. Mecm.* (B) **17** : 116 [relation to Israel form unknown].

Sergentomyia africana var. *asiatica* (Theodor), 1948 : 110 [Israel, N.-W. India] ; 1958 : 43.

Sergentomyia africana asiatica (Theodor, 1958).

Specimens presented to the British Museum (Nat. Hist.) by Sinton probably came from West Pakistan and accord with Theodor's descriptions.

He differentiated *S. a. asiatica* from the African form now known as *S. a. magna* by the absence in *asiatica* of punctiform cibarial teeth and the presence of more (45-50) horizontal teeth and few, long, pharyngeal teeth. Sinton's drawings show 38 and 48 horizontal teeth, respectively, in the two forms. Examination of *S. a. magna* from several areas shows that many specimens have about 50 horizontal teeth and no definite vertical ones, but *S. a. asiatica* can still be distinguished by its pharyngeal teeth.

The labrum of the male in *S. a. africana* Newstead (Text-fig. 49) and *S. a. asiatica* has a tapering crest.

Types. Types or syntypes in Jerusalem.

Distribution. Sinton's notes : Rhedia (near Larkana), Kandhkot, Shikarpur, all between 1930 and 1932.

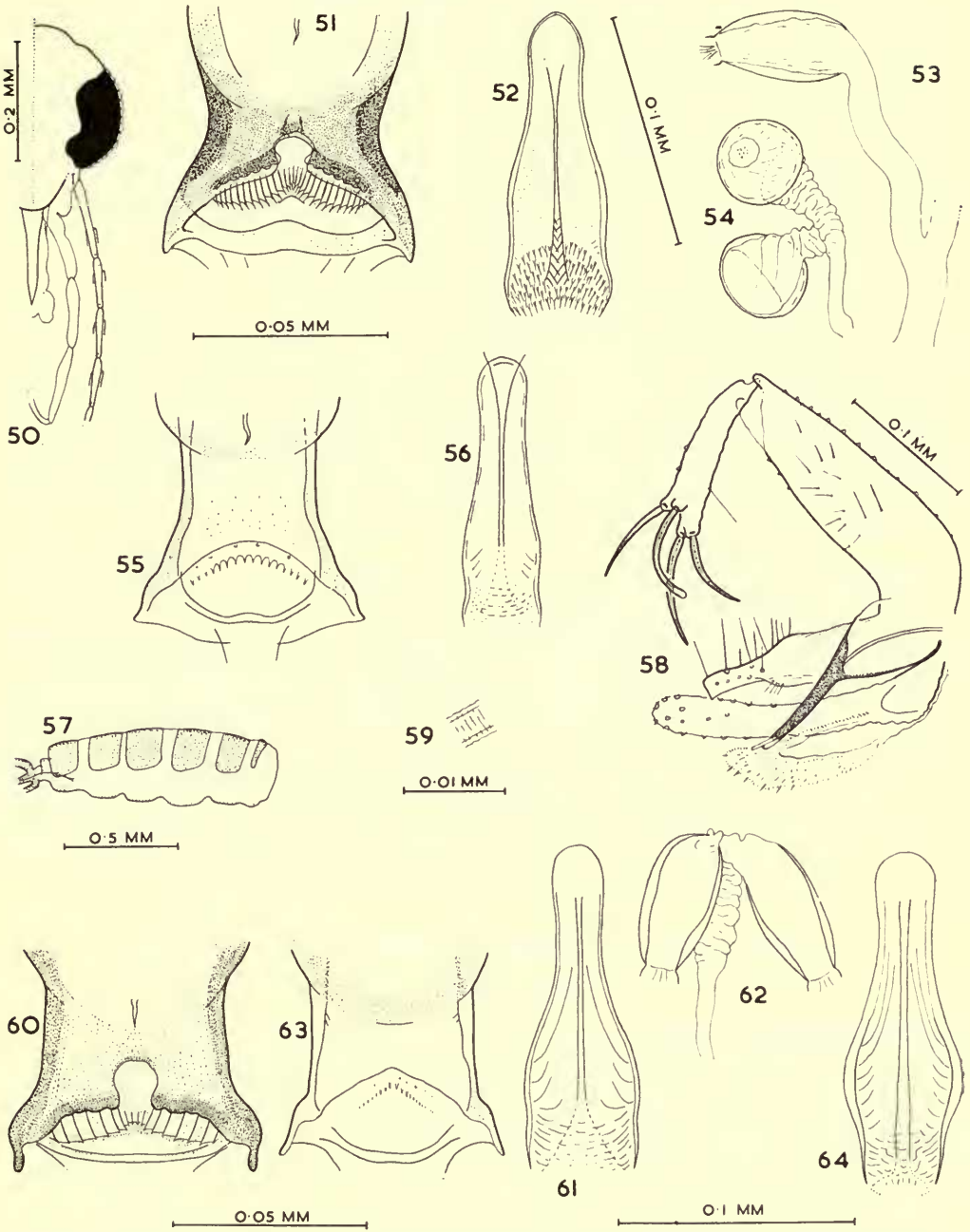
Sergentomyia (Parrotomyia) babu (Annandale)

(Text-figs. 50-59)

Phlebotomus babu Annandale, 1910, *Rec. Indian Mus.* **4** : 49 ; Sinton, 1932 : 60 ; 1933*d* : 422 ; Theodor, 1938 : 261 ; Quate, 1962*b* : 157.

Phlebotomus minutus var. *niger* ; Sinton, 1927, *Indian J. med. Res.* **15** : 31.

♀. Cibarium with about 30 nearly equal pointed teeth, the outer 12 or 13 on each side nearly parallel to each other and pointing slightly inward ; ventral plate often dark grey posteriorly, with a deep median notch of variable shape ; on each side of this notch the margin of the ventral plate is divided into a lower surface, with one or more protrusions, and an upper surface,



FIGS. 50-64. *Sergentomyia babu*, 50-54, ♀, 55-59, ♂. 50, head; 51, cibarium; 52, pharynx; 53, spermatheca; 54, spermathecae in end view; 55, cibarium; 56, pharynx; 57, abdomen; 58, terminalia; 59, genital filament. *S. baghdadis*, 60-62, ♀, 63, 64, ♂. 60, cibarium; 61, pharynx; 62, spermathecae; 63, cibarium; 64, pharynx.

above the roots of the teeth; chitinous arch ill-defined; pigment patch somewhat obscured by ventral plate, broad with its hind edge in line with the tips of the cibarial teeth. Pharynx narrowing to a varying extent behind the main bulge, teeth pointed. Labrum 0.16 (0.14-0.17) mm. long. Antennal segment 3 is 0.18 (0.17-0.21) mm. long, 1.0 (0.9-1.0) times length of 4+5, 0.8-0.9 length of labrum; segments 4+5 are 0.18 (0.16-0.20) mm. long; ascoids about 0.3 length of segment 4. Palpal formula 1-2-3-4-5, ratio about 10:12:13. Wing length 1.64 (1.49-1.87) mm., width 0.37 (0.31-0.45) mm.; R_2 is 0.7 (0.4-0.9) length of R_{2+3} ; R_1 apex is 0.3 (0.1-0.5) of R_2 . Spermatheca elliptical, greatest width about 3 times diameter at base of collar; thick-walled, junction with ducts partly flattened so that in some views the duct appears as a thin-walled extension of the spermathecal capsule; gland ducts and collar delicate, without distinct knob; spermathecal ducts short and thin-walled.

♂. Cibarial teeth often scarcely visible; about 10 in the centre are pointed, and about 5 on each side are often ill-defined; hind end of ventral plate markedly concave, the apex of the curve sometimes acute but seldom indented; chitinous arch ill-defined; pigment patch faint or absent. Pharynx with faint transverse ridges. Labrum 0.15 (0.14-0.16) mm. long, crest tapering as in *S. africana*. Antennal segment 3 is 0.16 (0.14-0.17) mm. long, shorter than 4+5, almost same length (0.9-1.1) as labrum; ascoid about 0.2 length of segment 4. Wing length 1.33 (1.30-1.39) mm., width 0.27 (0.24-0.32) mm. Dististyle with 2 apical and 2 subapical spines, and seta at about 0.65. Aedeagus mainly dark brown, curving slightly upward and tapering to a rounded colourless tip; genital filaments with conspicuous transverse ridges, about 2.2 times pump length. Parameres with truncated ends and lower corners extending downwards.

Specimens examined. Many from West Pakistan; 10 ♀ from Rawalpindi area and 10 ♂ from Lahore measured.

Sinton recorded a dark variant from Pusa, India, and Mitra and Roy (1952) described, as *P. thapari*, a form from Poona which may be a variant of *S. babu*.

Types. Lectotype ♂. Calcutta, India; Zoological Survey of India (Quate, 1962b).

Distribution. Sinton (1932): *S. babu* seems to have a wide distribution over the plains and foothills of India and Pakistan. Sinton (1933d): occurs between the areas of *S. baghdadis* and *S. shortii*. Sinton's notes: Cherat, Lahore. Present survey: Gilgit, Landi Kotal, Mir Muhammad, Rawalpindi, Said Pur, Taxila.

Sergentomyia (Parrotomyia) baghdadis (Adler & Theodor)

(Text-figs. 60-64)

Phlebotomus baghdadis Adler & Theodor, 1929: 281; Sinton, 1932: 60; 1932d: 422.

♀. Cibarium with about 18 pointed teeth, comprising about 4 small ones in the centre and about 7 large ones on each side; ventral plate with a deep median notch of varying shape, chitinous arch ill-defined; pigment patch broad, usually hidden by ventral plate. Pharynx with faint transverse ridges, and a few spicules at its hind end. Labrum 0.15 (0.14-0.17) mm. long. Antennal segment 3 is 0.16 (0.15-0.17) mm. long, same length (1.0-1.1) as 4+5, 1.0-1.1 times length of labrum; segments 4+5 are 0.16 (0.15-0.17) mm. long; ascoids about 0.3 length of segment 4. Palpal formula 1-2-3-4-5, ratio about 10:12:13. Wing length 1.62 (1.51-1.72) mm., width 0.35 (0.32-0.38) mm.; R_2 is 0.6 (0.3-0.8) length of R_{2+3} ; R_1 apex is 0.3 (-0.1 to 0.5) of R_2 . Spermatheca (like that of *S. babu*) with partly flattened outlet to duct; gland ducts and collar very delicate and lacking a distinct knob; spermathecal ducts short.

♂. Cibarial teeth usually scarcely visible, sometimes comprising about 6 central pointed teeth and a number of lateral spicules; hind end of ventral plate markedly concave; chitinous arch ill-defined; pigment patch faint or absent. Pharynx with a few transverse ridges. Labrum 0.15 (0.14–0.16) mm. long, with tapering crest. Antennal segment 3 is 0.17 (0.14–0.19) mm. long, slightly shorter than 4+5, 1.1 (1.0–1.2) times length of labrum; ascoid about 0.2 length of segment 4. Wing length 1.51 (1.39–1.64) mm., width 0.32 (0.28–0.36) mm. Abdominal tergite 6 nearly as wide as 5. Dististyle with 2 apical and 2 subapical spines, and seta at about 0.6. Aedeagus mainly dark brown, curving slightly upward and tapering to a colourless rounded tip; genital filaments about 2.5 times pump length. Parameres with truncated ends, lower corner directed downward.

Specimens examined. Many from West Pakistan, 10 ♀ and 10 ♂ from Peshawar area measured.

Sinton (1932) distinguished females of *S. baghdadis* from those of *S. babu* by the numbers of teeth given in the key, and considered that they and *S. shorttii* were closely related, but regarded them as species rather than varieties on account of their morphology and distribution. He (1933*d*) found the males difficult to distinguish without taking their distribution into account. Differences in the cibarial notch and the relative lengths of antennal segments 3 and 4+5 of certain individuals of *S. babu* and *S. baghdadis* (Adler & Theodor, 1929) do not hold for all specimens.

Types. 12 ♀ and 12 ♂ syntypes, from Baghdad and Basra; in Jerusalem; 131 ♀ and 1 ♂ were examined (O. Theodor, personal communication).

Distribution. Sinton (1932): in the west and north-west of the Indo-Pakistan subcontinent. B.M. (N.H.): Dera Ismail Khan, Jhelum, Kandhkot, Lahore, Rohri, Shikarpur, Sukkur. Sinton's notes: Bannu, Gujranwala, Jandola, Kashmore, Larkana, Lyallpur, Pano Aqil, Peshawar, Sarghoda, Tank. Present survey: Landi Kotal, Mir Muhammad, Rawalpindi, Said Pur, Taxila.

Sergentomyia (Parrotomyia) shorttii (Adler & Theodor)

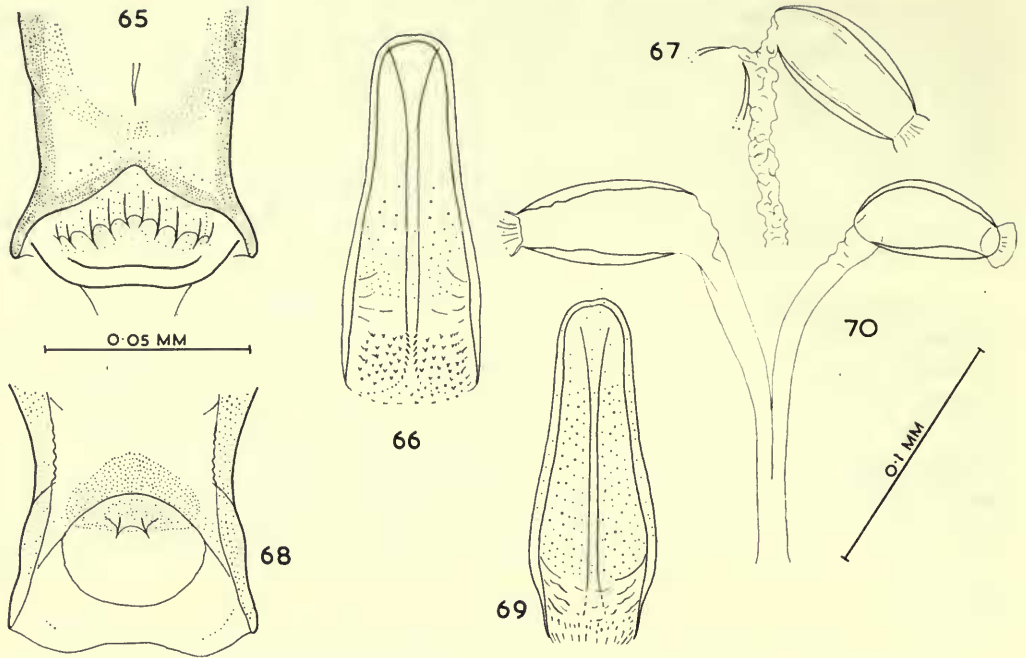
(Text-figs. 65–67)

Phlebotomus shorttii Adler & Theodor, 1927: 65; Sinton, 1928*b*: 317; 1932: 60; 1933*d*: 422.

♀. The one available specimen is damaged and was found far from the known area of *S. shorttii*, therefore the record requires confirmation. Some features are as follows. Pharynx robust, with few longitudinal folds, slightly pigmented in anterior 3/4, most of teeth short and pointed, some in groups. Labrum 0.17 mm. long. Antennae missing. Palpal formula 1–2–3–4–5; ratio 10:10:12. Wing length 1.57 mm., width 0.37 mm.; R_2 is 0.6 length of R_{2+3} ; R_1 apex is 0.4 of R_2 . Spermatheca elliptical, rigid part of capsule about the same width at each end.

Types. 8 ♀ and 8 ♂ syntypes from Golaghat, India; in Jerusalem.

Distribution. Sinton (1932): north-eastern India, and Burma. Sinton (1933*d*): eastern frontier of India, and in Burma. Qutubuddin (1944): Hyderabad (Deccan, India). Present survey: Taxila, 29.v.1959 (*H. C. Barnett*), in house, 1 ♀.



FIGS. 65-70. *Sergentomyia shortii*, ♀. 65, cibarium; 66, pharynx; 67, spermatheca. *S. sp. B.*, ♀. 68, cibarium; 69, pharynx; 70, spermatheca.

Sergentomyia (Parrotomyia) sp. B

(Text-figs. 68-71)

♀. The single specimen lacks appendages. The cibarium has two teeth, the pharyngeal armature comprises ridges and some minute posterior spicules, and the spermathecae are like those of *S. babu*. This may be a new species related to *S. shortii* but differing from it in the number of cibarial teeth and the nature of the pharyngeal armature.

Distribution. Present survey: Bahadur (near Peshawar), 12.vi.1959 (*H. C. Barnett*).

Sergentomyia (Parrotomyia) grekovi (Khodukin)

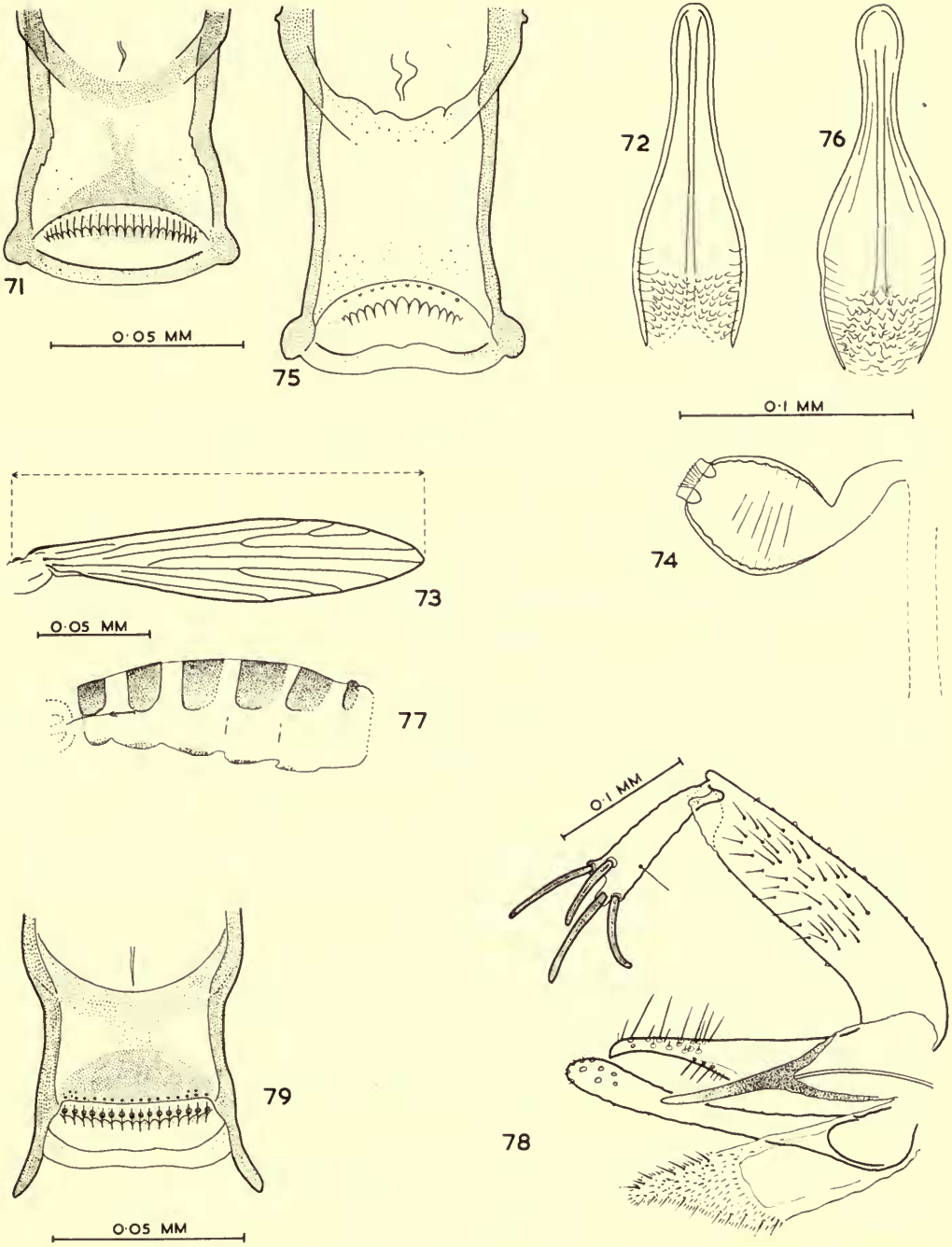
(Text-figs. 71-78)

Phlebotomus grekovi Khodukin, 1929, *Medit. Mysl' Uzbekist. Turkmenist. Suppl.*: 101.

Phlebotomus graecovi Perfil'ev, 1937: 127.

Sergentomyia grekovi (Khodukin); Theodor, 1958.

♀. Cibarium with knob-like postero-lateral margin and 18-24 parallel pointed teeth on an arch which is slightly concave posteriorly; a few punctiform teeth on each side; chitinous arch well defined at sides, postero-lateral edges of cibarium knob-like; pigment patch with an irregularly truncated forward extension and an irregular hind margin. Pharynx with thick walls and well marked posterior scales. Labrum 0.17-0.18 mm. long. Antennal segment 3 is



FIGS. 71-79. *Sergentomyia grekovi*, 71-74, ♀, 75-78, ♂. 71. cibarium; 72, pharynx; 73, wing; 74, spermatheca. 75, cibarium; 76, pharynx; 77, abdomen; 78, terminalia. *S. palestinensis*, ♀. 79, cibarium.

0.20-0.22 mm. long, shorter than 4+5, 1.2 times length of labrum; ascoids 0.3 length of segment 4. Palpal formula 1-2-3-4-5; ratio 10:11:11. Wings long and narrow, length 1.84-1.96 mm., width 0.36-0.38 mm.; R_2 short, 0.3-0.5 length of R_{2+3} ; R_1 apex is 0 or -0.7 in relation to R_2 . Spermatheca nearly spherical, with short collar, and wrinkles on inner surface of wall.

♂. Cibarium with about 12 parallel, pointed teeth on an arc slightly concave posteriorly, and punctiform teeth at their bases; chitinous arch well defined, postero-lateral edges of cibarium knob-like; pigment patch vestigial. Pharynx with scales and transverse ridges. Labrum 0.17 mm. long, crest truncated and pubescent as in *S. d. arpakensis*. Antennal segment 3 is 0.21 mm. long, shorter than 4+5, 1.2 times length labrum; ascoid 0.2 length of segment 4. Wing length 1.86 mm., width 0.33 mm. Dististyle with 2 apical and 2 subapical spines, and seta at 0.7. Aedeagus slightly upturned in distal half, with a blunt point, brown colouring gradually reduced from base to tip; filaments short, 2.5 times pump length. Parameres with beak-like down-turned ends.

Specimens examined. 2 ♀ and 1 ♂ from Gilgit.

Theodor notes that variation in the number of cibarial teeth may indicate the existence of different forms, and it is therefore interesting to find considerable variation in the two Pakistan females.

Distribution. Present survey: Gilgit, 11.vi.1963, sticky trap.

Sergentomyia (Parrotomyia) palestinensis (Adler & Theodor)

(Text-fig. 79)

Phlebotomus sp. Adler & Theodor, 1926: 404.

Phlebotomus palestinensis Adler & Theodor, 1927: 64; Theodor, 1947, *Bull. ent. Res.* **38**: 96;

Lewis, 1957, *Ann. Mag. nat. Hist.* **10**: 691; Perfil'ev, 1960.

Sergentomyia palestinensis (Adler & Theodor); Pringle, 1953, *Bull. ent. Res.* **43**: 719; Theodor & Mesghali, 1964: 295.

♀. In the one damaged female available there are 16 teeth, each with a nodular thickening near its centre; the chitinous arch and postero-lateral edges of the cibarium are prominent. The labrum is broad, as shown in the original figure, and 0.14 mm. long. Wing length 1.46 mm., width 0.32 mm.; R_2 is 0.4 length of R_{2+3} ; R_1 apex is -0.2 in relation to R_2 .

♂. In a male from Iran the labral crest is tapering.

The number and form of the cibarial teeth of the female support the conclusion of Theodor and Mesghali that this species may be very variable.

Type. Holotype ♀, from Jericho, Israel; in Jerusalem.

Distribution. Present survey: Peshawar, 25.vi.59 (*H. C. Barnett*), light trap, 1 ♀.

Sergentomyia (Grassomyia) squamipleuris indica (Theodor)

(Text-figs. 80-83)

Phlebotomus squamipleuris var. *indicus* Theodor, 1931, *Bull. ent. Res.* **22**: 470.

Phlebotomus squamipleuris; Sinton, 1923, *Indian. J. med. Res.* **11**: 65; 1932: 60; Perfil'ev, 1939 [in part]; Quate, 1962a: 259.

Sergentomyia squamipleuris var. *indica* (Theodor); Theodor, 1948 : 112.

Sergentomyia squamipleuris ssp. *indica* (Theodor); Theodor, 1958 : 47 [in part].

Sergentomyia indica (Theodor); Theodor & Mesghali, 1964 : 295.

♀. Cibarium with about 34-48 teeth in a posteriorly convex row, a line of punctiform teeth at their bases; chitinous arch weakly developed; wall of cibarium with inward projections behind teeth; pigment patch broad and dark. Pharynx brown, with convex outline behind the main bulge; many teeth present on the dorsal plate, partly hidden by spine-like teeth on ventral plates. Labrum 0.15 (0.14-0.17) mm. long. Antennal segment 3 is 0.14 (0.13-0.15) mm. long, shorter than 4+5, 0.9-1.1 length of labrum; ascoids single on segments 3-15, about 0.3 or 0.4 length of segment 4. Palpal formula 1-2-3-4-5; ratio about 10 : 11 : 13; Newstead scales on 2 (difficult to see) and 3. Femora without a row of spines. Wing length 1.65 (1.52-1.74) mm., width 0.38 (0.35-0.42) mm.; R_2 is 0.9 (0.7-1.1) length of R_{2+3} ; R_1 apex is 0.3 (0.1-0.5) of R_2 . Scales or their bases are to be seen on the pleura. Abdominal tergites dark brown; 3 with about 2-5 erect hairs on each side; in 3 out of 10 flies 2 hairs form the rudiment of a vertical line. Spermathecae with a compact mass of minute gland-ducts and a membrane, delicate or thick, surrounding their bases; surface of spermatheca smooth near its apex, otherwise marked with brown or colourless, small or very small, spicules, and often with some longitudinal lines; individual ducts of spermathecae sometimes about 4 times length of spermathecae but often contracted.

♂. Cibarium with about 22 teeth on a line slightly convex posteriorly; chitinous arch not very definite; lateral walls of cibarium with inward projections; pigment patch present. Pharynx with distinct but delicate teeth. Labrum 0.13 (0.13-0.14) mm. long, with wide transparent side pieces (as seen in lateral view), basal bulge pubescent, summit of crest rounded and projecting slightly forward. Antennal segment 3 is 0.15 (0.14-0.16) mm. long, shorter than 4+5, (1.1-1.2) times length of labrum; ascoid about 0.3 length of segment 4. Wing length 1.49 (1.42-1.61) mm., width 0.31 (0.29-0.34) mm. Abdominal tergites dark brown, tergite 6 slightly longer than 5 and curved dorsally. Dististyle with 2 apical and 2 subapical spines, and seta at about 0.75. Aedeagus curved upward and gradually narrowing except at the tip where it narrows abruptly to a rounded end. Genital filaments about 4 times pump length, with expanded ends. Parameres with rounded or truncated ends; the flattened inward surface of each faces slightly downward, and the curvature of the outward surface gives a beak-like appearance at certain angles of view.

Specimens examined. Many from West Pakistan; 10 ♀ and 10 ♂ from Peshawar area measured.

The tip of the paramere in this complex has been variously described as "rounded", a "bluntly-rounded point", a "truncate . . . blunt beak-like tip", and "hooked", to mention only a few terms; the discrepancies are probably due to a slightly variable structure being viewed from different angles.

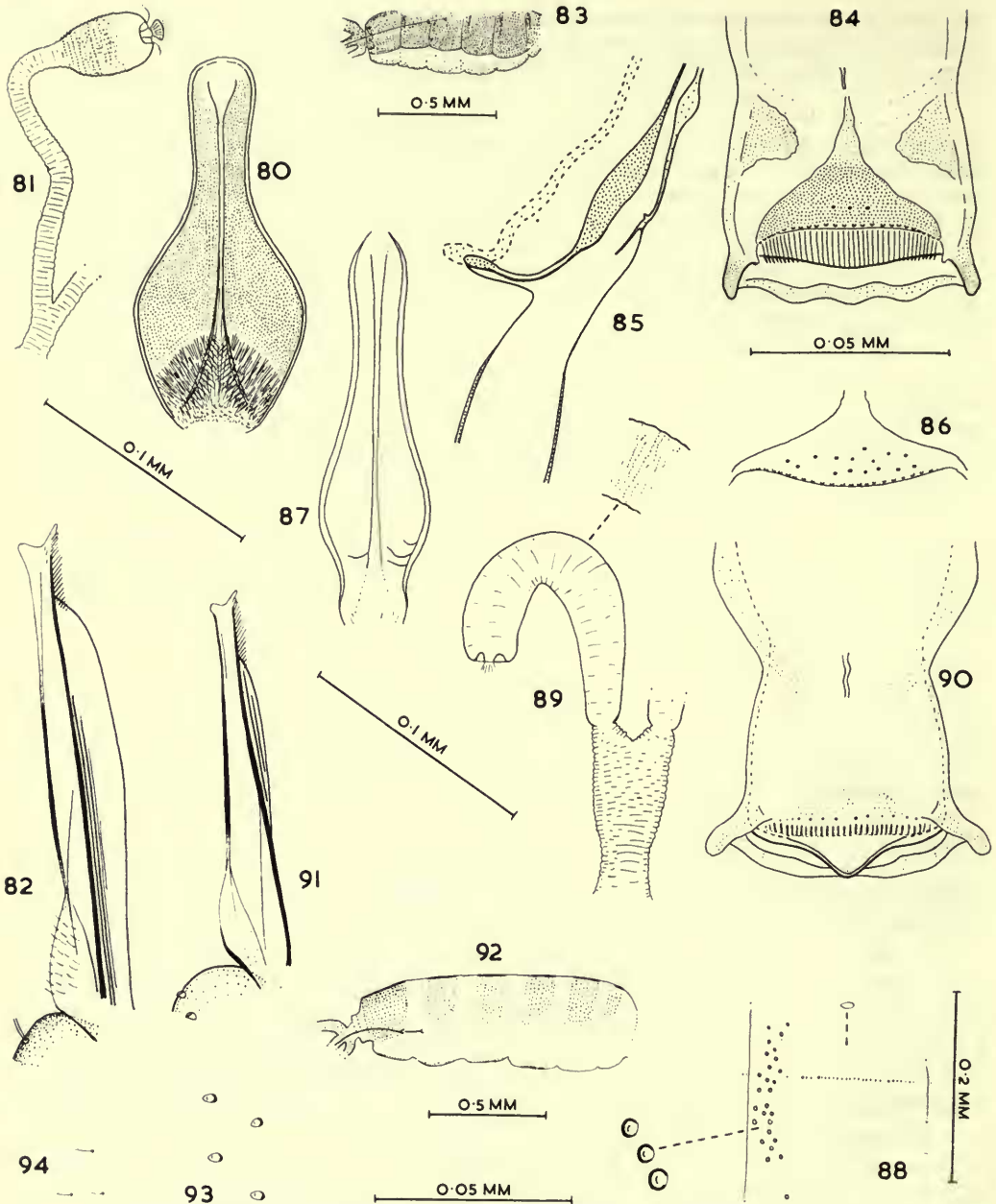
S. s. indica differs from *S. s. squamipleuris* (Newstead) in the shape of the pharynx and from *S. s. dreyfussi* (Parrot) in the absence of femoral spines, but is treated here as a subspecies because the differences are small.

Quate (1964) states that the spermathecal ducts of *S. s. squamipleuris* are short, but they are very like those of *indica* and any apparent difference may be due to contraction or the effects of different mounting media.

The variety *poonaensis*, first described and then named by Mitra & Roy (1953a, 1954) was not seen in Pakistan.

Specimens examined. Many from West Pakistan, 10 ♀ and 10 ♂ measured.

Types. Syntypes. INDIA: Karnal, 1 ♀, 1 ♂, 24.vii.1928; Saharanpur,



FIGS. 80-94. *Sergentomyia squamipleuris indica*, 80, 81, ♀, 82, 83, ♂. 80, pharynx; 81, spermatheca; 82, labrum; 83, abdomen. *S. pawlowskyi hodgsoni*, 84-89, ♀, 90-94, ♂. 84, 85, cibarium and semidiagrammatic optical section; 86, denticles of another fly; 87, pharynx; 88, hair scars on abdominal segment 3; 89, spermatheca; 90, cibarium; 91, labrum; 92, abdomen; 93, 94, some hairs or scars on abdominal segments 5 and 6.

3 ♀, 3 ♂, 29.vii.1929. WEST PAKISTAN: Jhelum, 1 ♂, 24.iv.1930. All collected by Sinton, now in Jerusalem. (O. Theodor, personal communication).

Distribution. Sinton (1927a): Lahore, Peshawar. Sinton (1932): it has a very wide distribution all over the Indo-Pakistan subcontinent, both on the plains and in the foothills up to 1,800 metres; a "garden species". B.M. (N.H.): Dera Ismail Khan, Jhelum, Khanki, Tank. Sinton's notes: Cherat. Present survey: Gujrat, Rawalpindi, Said Pur, Saidu Sharif (960 metres), Taxila.

Sergentomyia (Rondanomyia) pawlowskyi hodgsoni (Sinton) **stat. nov.**

(Text-figs. 84-94)

Phlebotomus hodgsoni Sinton, 1933b: 874; 1933d: 419.

Sergentomyia hodgsoni (Sinton); Theodor, 1948; Theodor & Mesghali, 1964: 296.

♀. Cibarium with about 40-60 long contiguous teeth in a nearly straight row, with a line of punctiform teeth at their bases; in front of these are about 4 additional punctiform teeth (0-15 in 21 cibaria examined); chitinous arch scarcely visible, postero-lateral parts of cibarium directed almost straight backward; each side of cibarium with large inward extension in front of chitinous arch; pigment patch broad and reddish brown with a conspicuous pale forward extension and a sharply defined hind edge formed by a posterior bulge in the dorsal wall of the cibarium. Pharynx with stout walls, a few transverse ridges, and some fine posterior spicules. Labrum 0.18 (0.17-0.19) mm. long. Antennal segment 3 is 0.14 (0.12-0.15) mm. long, shorter than 4+5, 0.8 (0.7-0.8) length of labrum; ascoid about 0.45 length of segment 4. Palpal formula 1-2-3-4-5; ratio 10:14:10:24. Body very pale. Wing length 1.78 (1.63-1.93) mm., width 0.42 (0.39-0.46) mm.; R_2 is 0.7 (0.4-1.0) length of R_{2+3} ; R_1 apex is 0.4 (0.2-0.5) length of R_2 . Abdominal tergites 2-6 with several large sockets of vertical hairs near hind margins. Spermatheca tubular with a distinct knob, no collar, and numerous fine transverse striations; each duct broad and similarly marked, joining a broad, thin-walled, wrinkled common duct.

♂. Cibarium with about 32 teeth in a nearly straight row, and a few denticles; chitinous arch almost invisible; pigment patch distinct but pale, with a hyaline bulge behind it. Pharynx with strong walls and posterior transverse lines. Labrum 0.16 (0.15-0.16) mm. long; crest with long dorsal thickening, and scarcely projecting rounded summit. Antennal segment 3 is 0.15 (0.14-0.15) mm. long, shorter than 4+5, same (0.9-1.1) length as labrum; ascoid about 0.3 length of segment 4. Wing length 1.64 (1.49-1.71) mm., width 0.39 (0.35-0.41) mm. Abdominal tergite 6 much longer than 5, with no hairs except large microtrichia. Dististyle with 2 of spines subapical, and seta on proximal half, at about 0.4. Aedeagus tapering to a blunt end; filaments about 3.6 times pump length. Paramere with beaked end and about 8 short spines on a small distinct ventral lobe.

The above description is based on that of Sinton, supplemented by notes by Theodor & Mesghali and by myself.

Sinton drew attention to the abdominal hairs of this species and thought it might belong to *Sintonius*. It has a striking resemblance to some members of this subgenus through the combination of cibarial characters, shape and texture of pharynx, body colour, abdominal hairs of female and of segment 6 of male, large abdominal tergite 6 of male and beaked parameres.

The reduction or loss of medium-size hairs on tergite 6 of male sand-flies seems to be associated with increasing size of the tergite (and possibly a concentration of fat-body) which is a feature of most species of *Sintonius*.

S. p. hodgsoni differs from *S. p. pawlowskyi* in having broad individual and common spermathecal ducts and, on the average, fewer denticles in front of the main row of cibarial denticles. The anterior denticles are difficult to count if the pigment patch is dark, as in Said Pur flies, and are not always in definite rows.

LECTOTYPE ♀. WEST PAKISTAN: labelled "Cherat, 1.vii.32, P. 263/B", in B.M. (N.H.), by present designation.

Paralectotype ♂. Locality as for lectotype, vi. 32, P. 267/B, in B.M. (N.H.), by present designation.

Distribution. Sinton (1933*b*): Cherat, Jandola, Landi Kotal. Present survey: Gwadi, Parkuta, Peshawar, Rawalpindi, Said Pur, Taxila.

Sergentomyia bailyi (Sinton)

(Group *nicnic*)

(Text-figs. 95–103)

Phlebotomus bailyi Sinton, 1931*b*: 822; Quate, 1962*a*: 260, 262.

Phlebotomus bailyi var. *campester* Sinton, 1931*b*: 823; Theodor, 1938: 268. Synonymy after Quate, 1962*a*: 262.

Sergentomyia bailyi (Sinton); Theodor, 1948.

♀. Cibarium with scarcely visible teeth arranged in a posteriorly concave row and small lateral groups; hind end expanded laterally; pigment patch small or absent; chitinous arch well developed. Pharynx with rows of minute spicules. Labrum is 0.16 (0.14–0.17) mm. long. Antennal segment 3 is 0.20 (0.18–0.22) mm. long 1.2–1.3 times length of labrum, equalling or longer than 4+5; ascoids about 0.5 length of segment 4. Palpal formula 1–2–3–4–5; ratio 10:10:11:24. Pleura very pale. Wing length 1.90 (1.63–2.20) mm., width 0.46 (0.40–0.50) mm.; R_2 about 0.90 length of R_{2+3} ; R_1 apex 0.3–0.5 length of R_2 . Spermathecae in the form of smooth capsules narrowing toward the apices, with very delicate ducts.

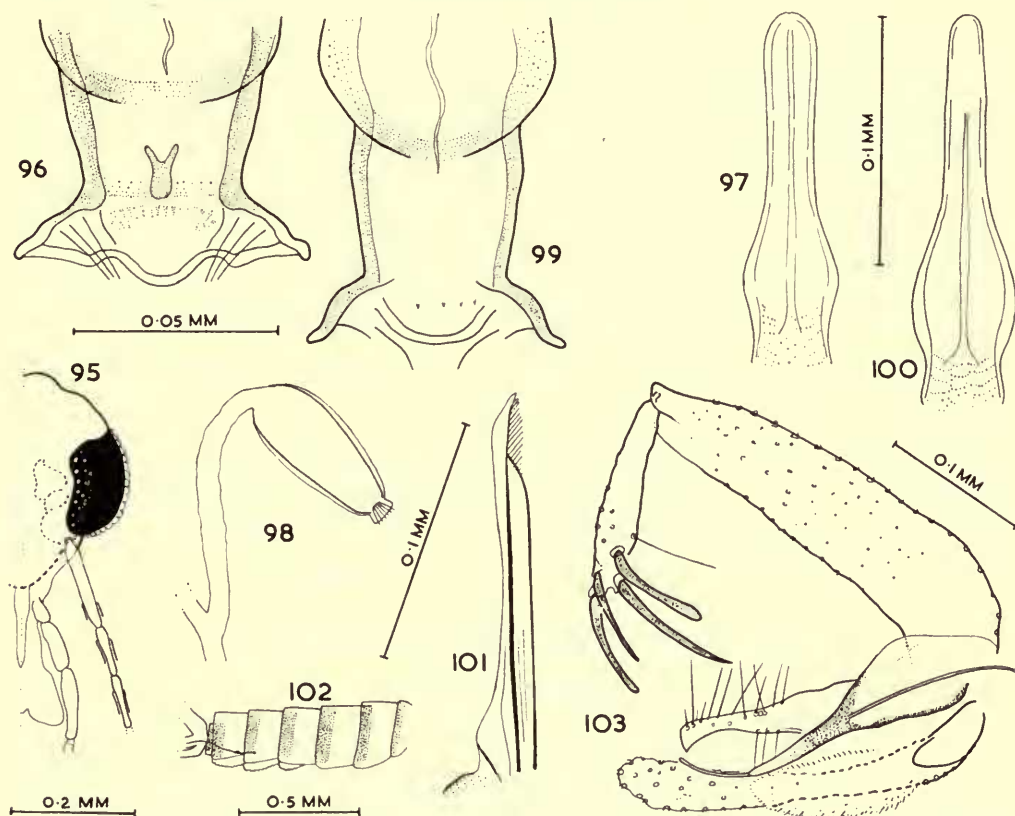
♂. Cibarium with scarcely visible pointed teeth in a posteriorly concave row; hind end expanded laterally; chitinous arch well developed; pigment patch small or absent. Pharynx with minute spicules. Labrum 0.15 mm. long, dorsal part shallow at centre, crest rising to a rounded summit and tapering distally. Antennal segment 3 is 0.25 (0.23–0.28) mm. long, 1.4 (1.3–1.4) times as long as labrum (10 from Taxila measured for this ratio), about equal to 4+5; ascoid about 0.2 length of segment 4. Pleura very pale. Wing length 1.93 (1.79–2.14) mm., width 0.39 (0.35–0.44) mm. Abdominal tergite 6 distinctly narrower than 5. Dististyle with 2 apical and 2 subapical spines, seta at 0.7, nearly level with subapical spines. Basistyle with many non-deciduous hairs on inner face. Aedeagus with colourless, bluntly-pointed, slightly up-turned tip; genital filaments 4 times pump length; paramere with beak-like apex.

This description is based on Sinton's and, apart from measurements, on examination of many specimens from West Pakistan.

The length of antennal segment 3, given in Sinton's (1933*d*) key to males, does not serve to separate all *S. bailyi* from *S. babu*.

This species and *S. montana* do not belong to any of the existing subgenera but it seems inadvisable to create new ones until related species (Theodor, 1948) are better known.

Distribution. Sinton (1931b): Dera Ismail Khan, Jandola, Lahore, Larkana area, Pano Aqil, Tando Muhammad Khan; very widely distributed in the Indo-Pakistan subcontinent, from sea level to 1,830 metres, much rarer than *S. babu* and usually forming not more than three per cent of *Sergentomyia* collections from the plains; common in hills where it is found with *P. major*, *P. chinensis* and *S. montana*. Qutubuddin (1951): Kohat-Hangu valley. Sinton's notes: Peshawar, Shikarpur, Tank. Present survey: Mir Muhammad, Rawalpindi, Taxila.



FIGS. 95-103. *Sergentomyia bailyi*, 95-98, ♀, 99-103, ♂. 95, head, 96, cibarium; 97, pharynx; 98, spermatheca; 99, cibarium; 100, pharynx; 101, labrum; 102, abdomen; 103, terminalia.

Sergentomyia montana (Sinton)

(Grouping uncertain)

(Text-figs. 104-III)

Phlebotomus minutus var. *montanus* Sinton, 1924a: 809; 1927c: 26.

Phlebotomus montanus Sinton, 1927, *Indian J. med. Res.* 15: 30; 1929: 174; 1932: 61; 1933d: 422.

♀. Cibarium with about 22 teeth in posterior row, the central 12 knob-like, small and contiguous, the outer 5 on each side widely spaced, pointed and inclined towards centre; in front of lateral teeth is a group of denticles on each side; chitinous arch well developed, with a brown strip behind it on each side; pigment patch with posterior upward projection, which looks like a dark brown refractive area, and a long wide anterior projection. Pharynx with a posterior network of fine ridges and a few spicules. Labrum 0.18 (0.15-0.19) mm. long. Antennal segment 3 is 0.23 (0.22-0.25) mm. long, longer than 4+5, 1.3 times length of labrum; ascoids about 0.3 length of segment 4. Palpal formula 1-2-3-4-5; ratio 10:11:12. Wing length 2.10 (1.18-2.29) mm., width 0.49 (0.36-0.54) mm.; R_2 long, 1.1 (0.9-1.3) times length of R_{2+3} ; R_1 apex is 0.6 (0.5-0.8) length of R_2 . Spermatheca a capsule with thick nearly-straight smooth walls, narrower at apex; knob small and collar well marked.

♂. Cibarium with about 14 teeth in posterior row and a group of about 4 denticles on each side; chitinous arch well-defined; pigment patch with postero-dorsal projection, usually appearing as a refractive area, and a long thin anterior process. Pharynx with a faint posterior network of fine lines. Head pale, so that the antennal sockets look like white patches. Labrum 0.17 (0.16-0.18) mm. long, crest truncated and pubescent, very like that of *S. theodori*. Antennal segment 3 is 0.30 (0.29-0.32) mm. long, slightly longer than 4+5, 1.8 (1.6-1.9) times length of labrum; ascoid about 0.15 length of segment 4. Wing length 1.98 (1.84-2.11) mm., width 0.39 (0.35-0.44) mm. Abdominal tergite 6 slightly smaller than 5. Dististyle with 2 apical spines, 1 subapical dorsal, and 1 inward-pointing spine behind it; and seta at about 0.4. Aedeagus tapering to a rounded point; filaments about 4.3 times length of pump which is narrow anteriorly. Paramere with beak-like apex and markedly down-turned point.

Specimens examined. 2 ♀ from Bahrein, 3 ♀ from Parkuta, and 1 (small) ♀ from Said Pur; 10 ♂ from Bahrein.

Distribution. Sinton (1924a): Murree. Sinton (1927a): Khaira Gali. Sinton (1932): occurs in the foothills of the western Himalayas at about 1,830 metres. B.M. (N.H.): Chitral road. Present survey: Bahrein (1,390 metres), Gilgit, Parkuta, Rawalpindi, Said Pur, Taxila.

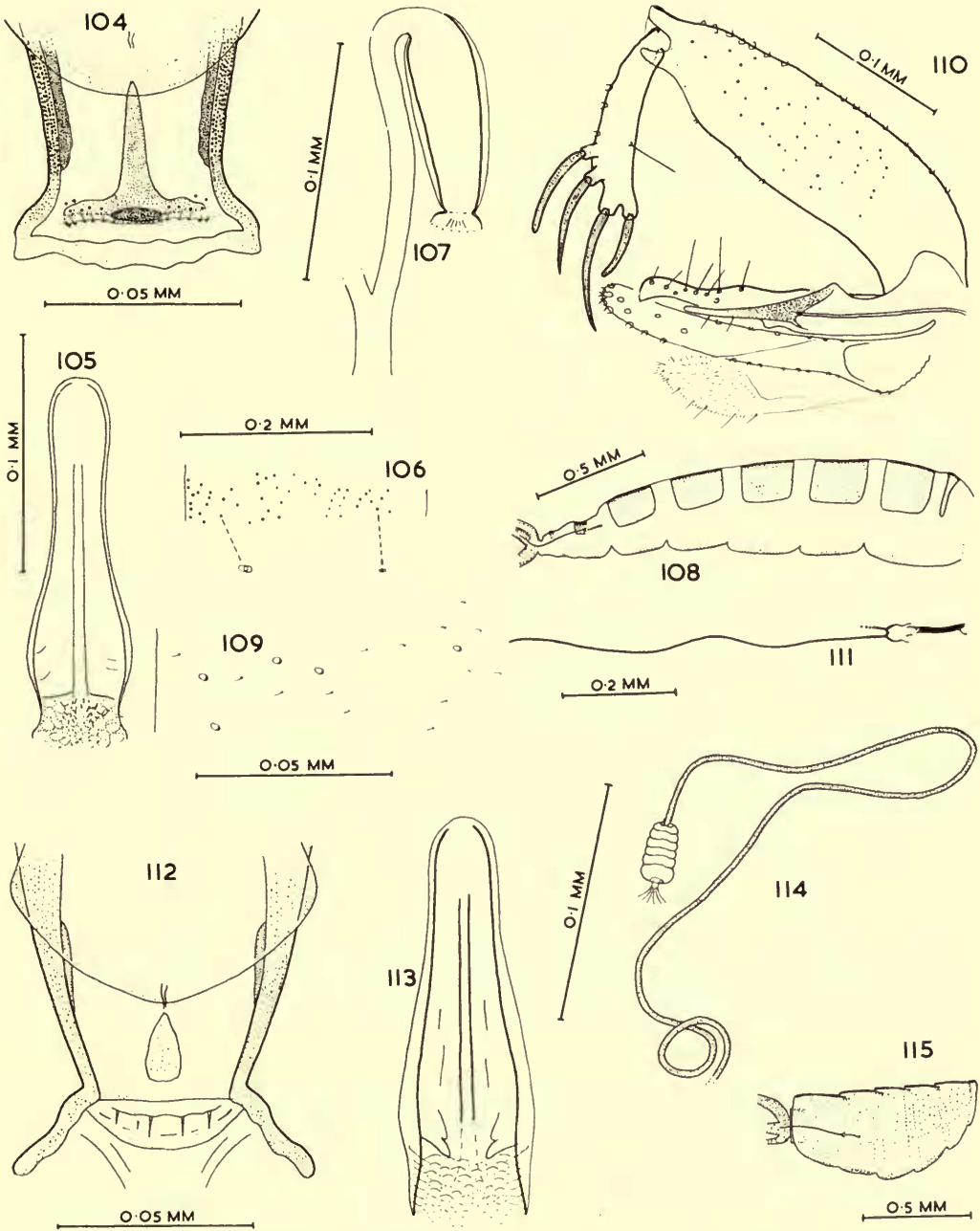
Sergentomyia (Sintonius) christophersi (Sinton)

(Text-figs. II2-II5)

Phlebotomus christophersi Sinton, 1927c: 22, 24; 1927d: 33; 1927, *Indian J. med. Res.* 15: 30.

♀. Cibarium with 4 or 5 widely spaced pointed teeth; chitinous arch pale, with lateral flanges; sides of cibarium are nearly straight and converge towards the hind end, postero-lateral corners divergent; pigment patch small and carrot-shaped. Pharynx not sharply contracted behind bulge, with a posterior network of fine lines. Labrum long, length 0.24 (0.22-0.25) mm. (in 5 flies). Antennal segment 3 is 0.13 (0.11-0.14) mm. long, slightly shorter than 4+5, 0.6 length of labrum (in 3 flies); ascoids about 0.4 length of segment 4. Palpal formula 1-2-4-3-5; ratio 10:14:9:21. Wing length 1.66 (1.57-1.73) mm., width 0.40 (0.35-0.43) mm.; R_2 is 0.6 (0.5-0.8) length of R_{2+3} ; R_1 apex is 0.4 (0.3-0.5) length of R_2 . Abdomen pale, with some erect hairs on hind margins of tergites. Spermatheca small, with 6-9 segments, no collar, a distinct knob, and a very long narrow duct with transverse thickenings.

♂. Cibarium with 2 or 3 teeth and several denticles; chitinous arch pale; postero-lateral corners of cibarium divergent; pigment patch carrot-shaped. Pharynx with transverse lines. Labrum 0.17 (0.16-0.18) mm. long (in 5 from Lahore), summit of crest projecting upward and forward as in *S. clydei*. Antennal segment 3 is 0.15 (0.14-0.16) mm. long, shorter than 4+5, 0.8 (0.7-1.0) length of labrum (in 5 from Lahore); ascoid about 0.3 length of segment 4. Wing length 1.55 (1.50-1.63) mm., width 0.37 (0.36-0.37) mm. Abdominal tergites 2-5 with some



FIGS. 104-115. *Sergentomyia montana*, 104-107, ♀, 108-111, ♂. 104, cibarium; 105, pharynx; 106, hair scars on tergite 3; 107, spermatheca; 108, abdomen; 109, hairs and scars on tergite 6; 110, terminalia; 111, genital pump and filament. *S. christophersi*, 112-114, ♀, 115, ♂. 112, cibarium; 113, pharynx; 114, spermatheca; 115, abdomen.

suberect hairs on hind margins, tergite 6 very large. Dististyle with 2 of spines subapical, and seta at about 0.6. Aedeagus tapering to a point, filaments about 3.8 times pump length. Paramere beaked.

The above description is based on Sinton's supplemented by my observations.

Distribution. Sinton (1927c): Lahore (about three per cent of sand-flies caught in jail in August and September; one elsewhere in May). Theodor & Mesghali (1964): Iran. Sinton's notes: Jhelum.

Sergentomyia (Sintonius) clydei (Sinton)

(Text-figs. 116-124)

Phlebotomus clydei Sinton, 1928a: 179; Perfil'ev, 1941 [pigment-patch variation].

Sergentomyia clydei (Sinton); Theodor, 1958; Lewis & Minter, 1960; Lewis & McMillan, 1961; Theodor & Mesghali, 1964; 297.

Sergentomyia clydei latiterga Theodor, 1958. Synonymy after Theodor & Mesghali, 1964.

♀. Cibarium with about 12 pointed teeth on a line which is slightly convex posteriorly at the centre; with a zigzag line of denticles; chitinous arch faint in the centre but with prominent lateral flanges; postero-lateral corners of cibarium not prominent; pigment patch broad and well defined. Pharynx narrowing considerably behind the bulge, with a few posterior lines and some rows of minute spicules. Labrum 0.22 (0.20-0.25) mm. long. Antennal segment 3 is 0.15 (0.14-0.17) mm. long, 0.9 (0.9-1.0) length of 4+5, 0.7 length of labrum; ascoid about 0.6 length of segment 4; segment 3 with 1-4 papillae, segment 4 with 1; palpal formula 1-2-4-3-5; ratio 10:12:10. Wing length 1.75 (1.60-1.93) mm., width 0.43 (0.39-0.48) mm.; R_2 is 0.7 (0.5-0.9) length of R_{2+3} ; R_1 apex is 0.3 (0.2-0.4) length of R_2 . Abdomen pale, with suberect hairs on hind margins of tergites 2-6. Spermatheca with about 9 segments, and long narrow duct and common duct (0.65 and 0.12 mm. long respectively in a fly with wing 1.77 mm. long).

♂. Cibarium with about 16-26 pointed teeth arranged in groups of 2-4, and an irregular row of denticles; chitinous arch faint; pigment patch about 0.4 width of cibarium. Pharynx with fine transverse lines. Labrum 0.19 (0.17-0.23) mm. long, summit of crest projecting forward and upward. Antennal segment 3 is 0.16 (0.15-0.18) mm. long, shorter than 4+5, 0.8 (0.8-1.0) length of labrum; ascoid about 0.45 length of segment 4; segment 3 with 1-3 papillae. Wing length 1.65 (1.55-1.74) mm., width 0.38 (0.35-0.41) mm. A few large hairs on abdominal tergites 2-5, tergite 6 with large microtrichia, wider than 5. Dististyle with 2 of spines subapical, and seta at about 0.7. Aedeagus short and tapering to a point, filaments about 4.5 times pump length. Paramere beaked.

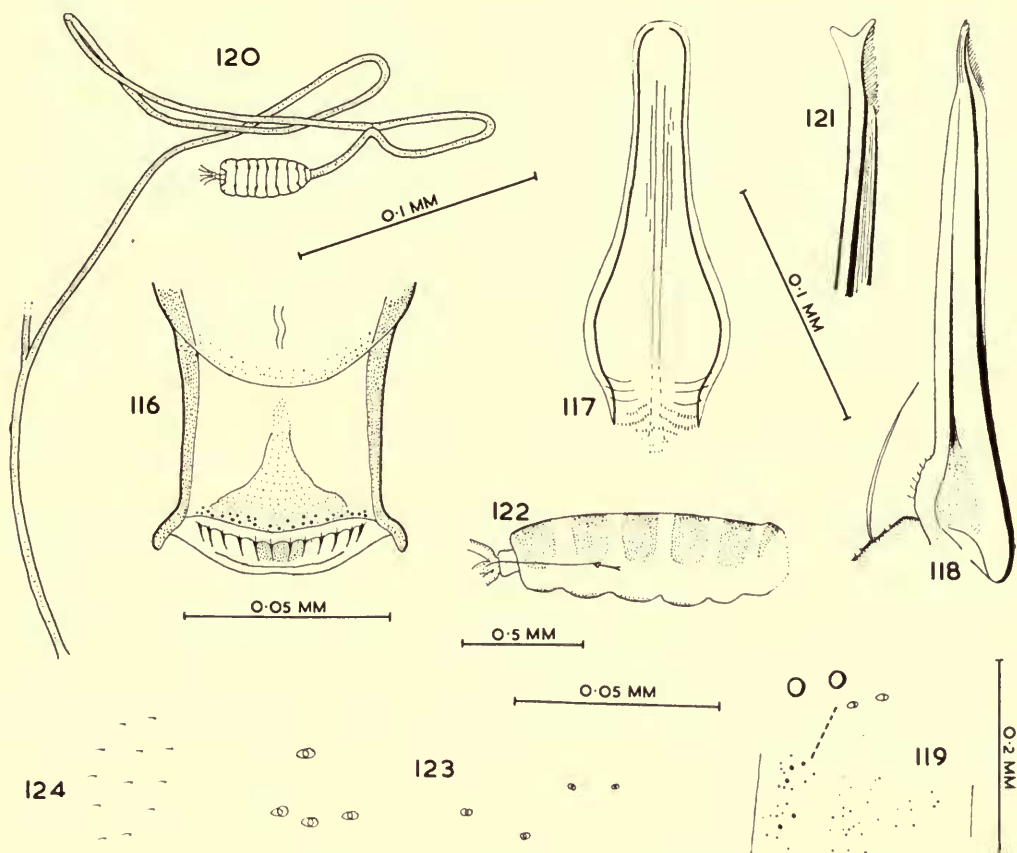
The above description is based on 10 ♀ and 10 ♂ from Rawalpindi.

In Africa many of the males have a large sixth abdominal tergite. In ten males from Rawalpindi the length of this tergite divided by that of the fifth ranged from 1.0 to 1.2 and averaged 1.05.

LECTOTYPE ♂. WEST PAKISTAN: Jandola, labelled "type ♂", in B.M. (N.H.), by present designation.

Distribution. Sinton (1928a): Jandola, Khirgi. Sinton (1932): recorded widely from the plains of the Indo-Pakistan subcontinent. Perfil'ev (1941): Central Asia. Pringle (1956): Iraq. Mesghali (1963): Iran. Theodor & Mesghali

(1964): Iran. Sinton's notes: Peshawar, Tando Muhammad Khan, Kairpur, Kandhkot. Present survey: Karachi, Lahore, Mir Muhammad, Rawalpindi, Taxila.



FIGS. 116-124. *Sergentomyia clydei*, 116-120, ♀, 121-124, ♂. 116, cibarium; 117, pharynx; 118, labrum; 119, hair scars on abdominal tergite 3; 120, spermatheca; 121, labrum; 122, abdomen; 123, 124, hairs or scars on abdominal segments 5 and 6.

Sergentomyia (Sintonius) hospitii (Sinton)

(Text-figs. 125-130)

Phlebotomus simillimus var. *hospitii* Sinton, 1924c: 261; 1927c: 22; 1927d: 30.

Phlebotomus hospitii Sinton, 1929: 174; 1932: 60; 1933d: 420.

Sergentomyia hospitii (Sinton); Theodor, 1948.

A large species with long antennal segment 3 and, in the ♂, a large tergite 6.

♀. Cibarium with about 70-80 long contiguous teeth on a posteriorly convex arc; chitinous arch well developed, with a brown area in front of it and 2 lateral blackish areas behind it; pigment patch very broad, mainly black except for the broad brown anterior extension.

Pharynx markedly restricted beyond bulge, with thick walls, a few transverse lines, and minute posterior spicules. Labrum 0.20 (0.18-0.21) mm. long. Antennal segment 3 is 0.28 (0.24-0.31) mm. long, 1.1 (1.1-1.2) times length of 4+5, 1.4 (1.2-1.5) times length of labrum; ascoid about 0.3 length of segment 4. Palpal formula 1-2-3-4-5; ratio 10:11:13. Wing length 2.18 (1.95-2.40) mm., width 0.56 (0.48-0.63) mm.; R_2 is 1.2 (0.9-1.4) length of R_{2+3} ; R_1 apex is 0.6 (0.5-0.7) length of R_2 . Femur 1 with about 6-8 short stout spines and 1 or more short thin ones. Abdominal tergites 2-5 with posterior patches of large suberect hairs. Spermatheca with about 9 segments and a long narrow duct.

♂. Cibarium with about 30 teeth on a posteriorly convex arc; chitinous arch well developed at sides, with a brown area in front of it and 2 lateral blackish areas behind it; pigment patch broad and blackish, without forward extension. Pharynx very like that of female. Labrum 0.20 (0.17-0.22) mm. long, crest well developed with non-projecting summit. Antennal segment 3 is 0.34 (0.31-0.38) mm. long, longer than 4+5, 1.7 (1.6-1.8) times length of labrum; ascoid about 0.2 length of segment 4. Wing length 2.30 (1.96-2.54) mm., width 0.59 (0.48-0.70) mm. Femur 1 with about 8-11 short spines of varying thickness, femur 3 with several long spines. Abdominal tergite 2 with a few large suberect hairs, tergite 6 very large, with microtrichia and no hairs. Dististyle with 2 of spines subapical, and seta at about 0.6. Aedeagus tapering to a point, filaments about 4.2 times pump length. Paramere beaked and rather dark.

The above descriptions are based on 10 ♀ and 10 ♂.

The femoral spines are difficult to count because some are rather like hairs and usually several are missing.

LECTOTYPE ♂. KASHMIR: Dulai, 21.ix.23, presented by Sinton in 1950 and labelled "type ♂ of Kr 2" (Kr 2 referring in his notes to locality and date), in B.M. (N.H.), by present designation.

Paralectotype ♀. Locality and date as for lectotype, labelled "co-type ♀ Kr 2", B.M. (N.H.), by present designation.

Distribution. Sinton (1924c): Dulai. Sinton (1932): recorded only from the western foothills of the Himalayas. Present survey: Abbottabad area, Chilas, Rawalpindi, Said Pur.

Sergentomyia (Sintonius) tiberiadis Adler, Theodor & Lourie

(Text-figs. 131-133)

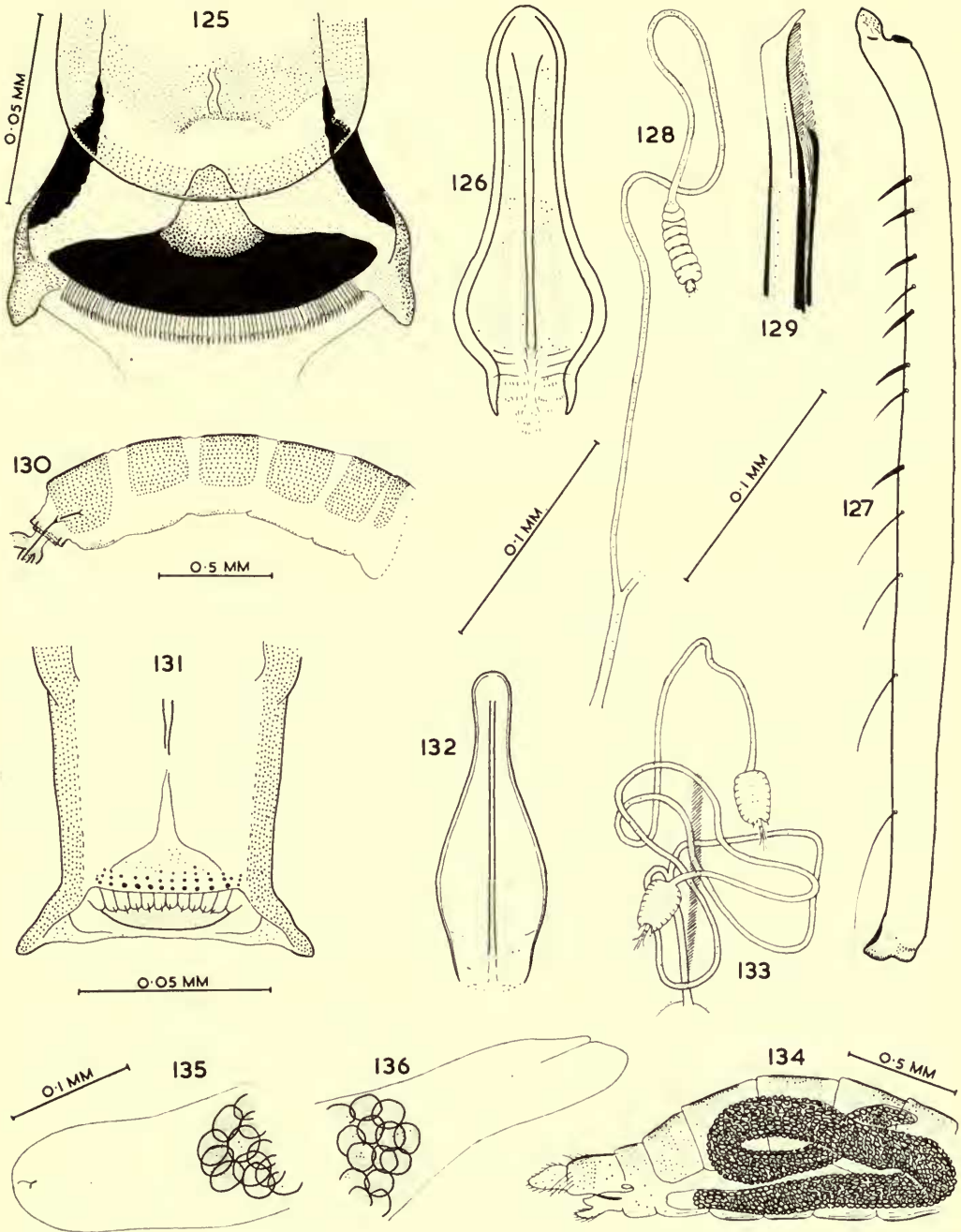
Phlebotomus sp. near *clydei* Adler & Theodor, 1929: 284.

Phlebotomus tiberiadis Adler, Theodor & Lourie, 1930, *Bull. ent. Res.* **21**: 537; Parrot & Clastrier, 1960.

Phlebotomus subtilis Parrot & Martin, 1939, *Archs Inst. Pasteur Algér.* **17**: 151. Synonymy after Theodor, 1953, *J. Washington Acad. Sci.* **43**: 121.

Sergentomyia tiberiadis; Theodor, 1958; Theodor & Mesghali, 1964: 297.

♀. Cibarium with 12 teeth, their points directed upward and often hidden; 1 or 2 rows of large denticles present, and often small denticles in front of them, which may be in a row or in central and lateral groups; chitinous arch indistinct; postero-lateral corners of cibarium prominent; pigment patch distinct, nearly as broad as armature, with long forward extension and posterior bulge; sclerites at bases of stipites conspicuous. Pharynx thin-walled, narrowing gradually behind bulge, almost smooth posteriorly. Labrum 0.19 (0.17-0.20) mm. long. Antennal segment 3 is 0.17 (0.16-0.18) mm. long, 0.9 length of 4+5, 0.9 (0.8-0.9) length of



FIGS. 125-136. *Sargentomyia hospitii*, 125-128, ♀, 129, 130, ♂. 125, cibarium; 126, pharynx; 127, femur I; 128, spermatheca; 129, labrum; 130, abdomen. *S. tiberiadis*, ♀. 131, cibarium; 132, pharynx; 133, spermathecae. Nematode parasites. 134, 135, from *P. papatasi*; 136, from *S. clydei*.

labrum; ascoid about 0.4 length of segment 4. Palpal formula 1-2-4-3-5; ratio 10:14:9. Wing length 1.50 (1.36-1.61) mm., width 0.32 (0.30-0.33) mm.; R_2 is 0.5 (0.1-0.7) length of R_{2+3} ; R_1 apex is -0.7 (-2.0 to 1.0) in relation to R_2 . Abdominal tergites 2-6 with a few large suberect hairs. Spermatheca small, narrowing towards apex, with about 9 faintly discernible segments, the knob ending in a refractive tip from which the gland ducts extend; duct long and narrow, leading to short common duct.

♂. One male from Rawalpindi is probably this species. Its labral crest is like that of *S. clydei*.

Specimens examined. 4 ♀ (palps of 2 and wings of 3).

The Pakistan form differs from that described by Theodor in the shortness of R_1 , the shape of the spermathecae, and the union of their ducts. The spermathecal characters are difficult to evaluate from the examination of a few preserved females from one area, and I am therefore not naming the Pakistan form as a species or subspecies at present.

Types. 2 ♀ and 4 ♂ syntypes, Tiberias, Israel; in Jerusalem.

Distribution. Present survey: Ahmad Khel, Landi Kotal, Peshawar.

ZOOGEOGRAPHY

Faunal subregions represented in West Pakistan. In Wallace's zoogeographical map of the world (Bartholomew *et al.*, 1911) West Pakistan includes parts of the Mediterranean and Siberian subregions of the Palaearctic region, and part of the Indian subregion of the Oriental region. The Ethiopian region must also be considered here because, although far away, it has close relations with the Oriental (Gressitt, 1958).

These two Palaearctic subregions include the Eremian zone of Uvarov (1938) which extends from the western Sahara to Central Asia and has sometimes been treated as a distinct region. It has a particular significance for eremic sand-flies, for which it may serve as a link between regions instead of a barrier. The Turkestan desert is part of the great Palaearctic desert zone and some groups in its fauna include immigrants from Africa (Heptner, 1938). Kryzhanowsky regards Middle Asia as the most important centre of origin of the desert fauna of the northern hemisphere (Uvarov, 1965).

Faunal boundaries used in and near West Pakistan vary according to the animals studied; Wallace includes Peshawar in the Mediterranean subregion, Gilgit in the Siberian, and Karachi and Lahore in the Indian; and Maxwell-Lefroy (1909) adopts a rather similar system. His ecological zones, with approximate heights in metres, are: tropical (0-600), subtropical (600-1,800) and temperate (with Palaearctic fauna) (above 1,800). The Himalayas, according to Darlington (1957), are only a partial zoogeographical barrier and less important than climatic differences. The western Himalayas have brought the Palaearctic boundary southward (Mani, 1962); it has been placed at 2,000 and 3,000 metres but varies from place to place and is partly determined by latitude and the intrusion of southern forms along river valleys. The West Pakistan Himalayas lie well within the western Himalayan botanical province (Stearn, 1960).

The West Pakistan fauna in general. Reference to a few zoogeographical works will indicate the general nature of the fauna which is a blend of the Palaearctic and Oriental faunas (Munroe, 1965). Darlington (1957) points out that the fauna is impoverished and that the Himalayas permit some Oriental species to spread northward. The north-western Himalayas show a marked dominance of Palaearctic and endemic animals (Mani, 1962), and endemic Hemiptera have been discussed by Hutchinson (1934). The Hemiptera of north-west Pakistan have substantial Palaearctic affinities but include Oriental elements (Ghauri, 1965). Some 70 per cent of the West Pakistan Trichoptera are Oriental and some species are widely distributed, but this order is poorly represented, perhaps because some main centres of dispersal are far away (Schmid, 1958). Christophers (1933) found that most typically Oriental anopheline mosquitoes tended to become scarce before reaching their western limits but that some alpine forms, which occur from about 900 to 2,400 metres up, extended to the Hindu Kush in Chitral and perhaps beyond. Qutubuddin (1960a, b) noted a mixture of Palaearctic and Ethiopian mosquitoes in the north and north-west of West Pakistan, and Lundblad (1934) found a poor hydracarine fauna in the western Himalayas.

The phlebotomine fauna. The forms known in West Pakistan are those listed in Table II and *P. colabaensis*, *S. d. dentata*, *S. a. asiatica* and *S. grekovi*. They comprise some 29 species and one local subspecies, and ten or more other species may be expected to occur. Thus the number of forms is considerable, owing to the above-mentioned desert link, the mingling of regional faunas, and the fact that many sand-flies flourish in dry conditions.

The distribution of many of the species in the Palaearctic region has been discussed by Theodor (1952, 1964). Some Pakistan species are too widely distributed in the world to be described as elements of a particular region or subregion, and some forms, although confined to one subregion, are closely related to species of another subregion. Therefore, in discussing the Pakistan species according to their general distribution and taxonomic relationships, it is only possible to group them very loosely.

Species with a largely Mediterranean distribution are *P. papatasi*, *P. alexandri*, *P. sergenti*, *P. major*, *S. dentata* and *S. theodori*, and they reflect the importance of the genus *Phlebotomus* in that area. *S. papatasi*, *P. sergenti*, *S. d. arpaklensis* and *S. theodori* are widely distributed in West Pakistan but *P. papatasi* was noticeably absent in the Keris area. *P. major* seems to be associated with the northern hills.

S. africana, *S. christophersi*, *S. clydei* and *S. tiberiadis* are among the species with Ethiopian affinities. *S. christophersi* seems to have a very sporadic distribution and one of its few known localities is in the Palaearctic (Iran). Of these four species, only *S. clydei* appears to be widely distributed in West Pakistan.

Species with central Asian affinities are *P. nuri*, *P. kandelakii*, *P. keshishiani*, *S. grekovi*, *S. palestinensis* and *S. pawlowskyi*. *P. chinensis* may conveniently be included although it extends from the eastern Mediterranean to China and south to Arabia. All these species occur in or near the northern hills, and *Phlebotomus* predominates, for example around Keris, where 96 per cent of specimens collected belonged to that genus.

Oriental species are *P. argentipes*, *P. colabaensis*, *S. punjabensis*, *S. babu*, *S. shorttii*, *S. bailyi*, *S. montana* and *S. hospitii*, and *S. baghdadis* is closely related to two Oriental species. *S. sq. indica* may be mentioned here but it belongs to a very unusual species, or possibly complex, which extends from West Africa to China (Leng, 1964) and Malaya. The rarity of *P. argentipes*, *P. colabaensis* and *P. shorttii* at their western limits was to be expected. *S. montana* is perhaps comparable with the above-mentioned hill anophelines which extend far to the west. *S. hospitii* also occurs among or near hills and is localized but not rare. *S. punjabensis*, *S. babu*, *S. baghdadis* and *S. bailyi* are widely distributed, and Table II illustrates the easterly distribution of *S. babu*, which was pointed out by Sinton. The abundance of this species and *S. baghdadis* is comparable to that of the related *S. africana* in Africa.

On the basis of present knowledge it is possible to summarize some general features of the sand-fly fauna. Most of the Palaearctic species belong to the genus *Phlebotomus*. The fauna somewhat resembles the northern Ethiopian sand-fly fauna; several species occur in both areas, including the common *P. papatasi*, *S. squamipleuris* and *S. clydei*, and in each case one or more abundant species belong to the subgenus *Parrotomyia*. In West Pakistan most species with Mediterranean or Oriental affinities occur in the "tropical" zone, and Central Asian forms are found in or near the northern hills. The composition of the fauna is comparable to that of some other groups of animals but the number of species is quite large.

P. argentipes and some other rare species. Of the sand-flies known in West Pakistan few species have been found in large numbers, two forms were not encountered at all in the present survey, and eight were represented by single specimens. It is a common experience to find a sand-fly species only after examining hundreds or even thousands of specimens, and this is sometimes due to selection of some species by the special methods of collecting which are necessary for these insects.

P. argentipes, being the main vector of kala-azar in eastern India, is of particular interest. Sinton (1925c) reported that it occurred in Ceylon and seemed to be widespread along the coast of India at heights below 460 metres. He stated (1927b) that it was known far inland but not west of a line joining Delhi and Bombay, and occurred at Saharanpur, north of Delhi and Sanawar above 1,200 metres in the Simla Hills. He had previously examined thousands of sand-flies from the Sanawar area during seven years (1927e), and he commented on the localization of the species. Sinton (1928b) reported it from Burma and expected it to exist in Malaya where it is now known, and (1932) remarked that it was favoured by a moist climate. Qutubuddin (1944) found *P. argentipes* at Hyderabad, India. Mitra (1954a) pointed out that it had previously been known from warm damp country below 1,220 metres, and reported it from cool dry country up to 1,520 metres in Bombay State and from one place in the Kathiawar Peninsula which is near Pakistan. The species also occurs in Indo-China.

An L-shaped line drawn through Kathiawar, Delhi, Lahore and Rawalpindi approximates to the 600 mm. isohyet (Imperial Gazetteer, 1931). The northern arm of this line may also represent a discontinuous extension of *P. argentipes* parallel to

the northern foothills, where it possibly occurs in certain irrigated areas with dense shade. Near Taxila the orchard of Nikra is a contrast to the barren country around, and in the Lahore area this species has been found near trees (Nasir, 1964). The work of Mitra (1956, p. 237) and Smith (1959) suggests that searches might profitably be made in cattle sheds and houses, particularly in dark corners and crevices near the floor.

BIOLOGY

Seasonal prevalence. Sinton (1924b) reported that sand-flies might vanish for several months in very cold winters, and that they appeared about the end of March and were very abundant by the end of April, their numbers diminishing in the hot dry summer months of June and July and increasing again in the damp weather of August. My visit in 1963 followed an unusually cold winter and sand-flies were not numerous around Lahore in early May or Rawalpindi in late May, but were easy to find in the Keris area in late June.

Habitat. There is much to be learnt about the natural habitats in which most species of sand-flies live. Lupascu *et al.* (1965b) in Rumania found that species of *Paraphlebotomus*, *Larroussius* and *Adlerius* were wild sand-flies and might act as vectors of disease in the natural environment. *P. major* in particular occurred in natural shelters (Lupascu, Dancescu & Cheles, 1965) and seldom approached human settlements (Lupascu *et al.*, 1965a). In the Soviet Union species of *Larroussius*, which have large spiracles, predominate in damp areas (Dolmatova, 1962), and in Transcaucasia the hygrophilous *P. kandelakii* occurs in gardens rather than natural habitats, but *S. d. arpaklensis* is xerophilous and rarely enters villages (Dergacheva, 1959).

The common endophilic sand-flies of West Pakistan include *P. papatasi*, *P. sergenti*, *S. babu* and *S. baghdadis*. The figures in Table II indicate absence of *P. caucasicus* Marzinowsky and scarcity of *Larroussius*, as compared with collections near Tehran in Iran (Lewis *et al.*, 1961). During May, 1963 few *P. papatasi* or *P. sergenti* were found in Pakistan houses except *bura* or underground dwellings near Taxila. During June in the Chilas and Keris areas it was difficult to find sand-flies in houses, probably because people tend to sleep on the flat roofs in summer. Residual spraying might, therefore, be ineffective there at this season, as in the case of *Anopheles sergenti* in parts of Israel and Jordan (Chang, 1965).

With regard to types of outdoor habitat, Dolmatova & Dergacheva (1961) and Dolmatova *et al.* (1962) found that *P. papatasi*, *S. d. arpaklensis* and *S. grekovi* were common in burrows of the large gerbil which appeared to be the natural reservoir of cutaneous leishmaniasis around Karshi in Uzbekistan.

In East Africa kala-azar is associated with certain termite hills in which the vector rests. Other species have this habit, however, in Kenya, Brazil (Martins *et al.*, 1964) and Ghana. During the present survey *S. babu* and *S. bailyi* were caught in two termite hills in Lahore, and it seems that these structures harbour many sand flies in places with few other natural shelters.

Blood feeding. *P. papatasi* and *P. sergenti* are probably the most widespread and numerous man-biting endophilic species, and some other species of *Phlebotomus*

doubtless bite man in some areas. Several species of *Sergentomyia*, including *S. clydei*, sometimes bite man in Africa. A female of *S. baghdadis* was included in a collection of *P. papatasi* taken on man at Mir Muhammad, suggesting that further catches on human and animal bait might yield new information. Sand-flies from Shahzada labelled "biting cattle" included male and female *P. papatasi* and males of *P. sergenti*, *P. argentipes* and *S. punjabensis*. It might be thought that the presence of males was due to an unusual chance, but this is not necessarily so, for in Central America males of at least one species sometimes accompany females when they are biting man.

Some features of sand-flies in the Keris area. In this kala-azar area sand-flies were collected at Gol, Gwadi (2,560 metres), Keris (2,530 metres) and Parkuta. The average number of flies per trap per village was 0.1 to 2.4, and most of the specimens were males. Sand-flies caught in houses in 1960 (most in June and very few in September) comprised 7 *P. sergenti*, 20 *P. k. burneyi*, 5 *P. c. longiductus* and 1 *S. montana*. All the others were taken in June, 1963 on sticky traps, more being found near houses and rocks than among cultivation. The complete total for both sexes comprised 1 *P. alexandri*, 74 *P. sergenti*, 23 *P. k. burneyi*, 2 *P. keshishiani*, 89 *P. c. longiductus*, 2 *S. d. arpakensis*, 2 *S. p. hodgsoni* and 3 *S. montana*. The high proportion of *P. k. burneyi* in the 1960 collection suggests it is somewhat endophilic. Perfil'ev (1941) describes *P. chinensis* and related sand-flies in the U.S.S.R. as "cave species", found mainly out of doors where they attack man. Col. Burney informs me that he was once bitten by many sand-flies in a tent at night in the Keris area but found few in the morning. Many of the *P. c. longiductus* in this area probably come from rocks near villages. In view of the possible existence of a wild-animal reservoir of leishmaniasis, 18 traps were set about 3 km. from Parkuta up the Indus valley. Three flies were caught, *P. c. longiductus* and *S. p. hodgsoni* in the desert and *P. keshishiani* near the river.

At a lower altitude, 1,490 metres around Gilgit, sticky traps in 1963 caught 9 *P. sergenti*, 5 *P. c. longiductus*, 1 *P. keshishiani*, 4 *S. babu*, 3 *S. grekovi* and 1 *S. montana*.

Some parasites. In 1963 single specimens of a relatively large nematode about 3.7 mm. long (Text-figs. 134-136) were found in the abdomen of a teneral female *P. papatasi* from Taxila, a teneral male *P. sergenti* from Gilgit, and a female *S. clydei* from near Karachi. Each worm was folded at two points and was almost full of oval or nearly spherical brown eggs about 0.027 to 0.03 mm. long. The *P. papatasi* also contained the empty skin of another worm. This parasite can evidently attack quite different species in widely separated areas and seems likely to kill its host and liberate eggs in the soil. It may be that many larvae and pupae are infected but few reach the adult stage. A worm infesting *P. papatasi* and *P. sergenti* in Iraq (Adler & Theodor, 1929) may be the same species, but the nematode found in Indian *P. papatasi* by Mitra (1956) is evidently different.

A few mites have been recorded by Jenkins (1964) and others on sand-flies in various countries. Some were found during the present survey and have been examined by Mr. D. Macfarlane, together with J. A. Sinton's specimens from the

London School of Hygiene and Tropical Medicine put at our disposal by Dr. B. R. Laurence. The following notes show that several species occur on various phlebotomines in the subcontinent. Further study may show how specific the true parasites (*Stigmaeus*, *Ledermuelleria* and trombitiids) are, and what the sand-flies are doing when they pick up the passenger species. *Typhlodromus* is one of the genera of Mesostigmata and the others are Prostigmata.

Typhlodromus sp. (Phytoseiidae), 2 on *P. chinensis* from Kasauli.

Stigmaeus smithi (Mitra & Mitra, 1953) (= *Raphignathus smithi*), type specimen on *P. papatasi* near Poona (Mitra, 1956).

Stigmaeus youngi (Hirst, 1926) (= *R. youngi*) on ♀ *P. papatasi* at Jamesabad, ♂ *P. papatasi* at Mir Muhammad, ♀ *P. papatasi* at Peshawar, and several *S. dentata* or related form at Lahore. Young *et al.* (1926) found that these grey mites, together with less common red trombitiid larvae, infested about four per cent of *P. papatasi*, mainly females, at Peshawar, and Lewis and Minter (1960) reported a species of *Stigmaeus* from Kenya.

Ledermuelleria sp. (Stigmaeidae), a grey mite, on ♀ *P. papatasi* at Jandola, several *P. papatasi* at Lahore, ♀ *P. papatasi* at Peshawar, ♀ *P. papatasi* at Sadhana (several nymphs, associated with brown abdominal scars of the host), and ♀ and ♂ *P. major* at Kasauli. Most stigmaeid mites are apparently free-living, and all the parasitic ones have been found on sand-flies, namely the two *Stigmaeus* mentioned above and *Ledermuelleria* from Central America (Chaudhri, 1965) and West Pakistan. This association is doubtless partly due to the fact that sand-flies, unlike most blood-sucking flies, breed in soil.

Trombitidium hindustanicum Hirst, 1926, type larva on *P. papatasi* at Peshawar.

Trombitiid larvae of various species on several ♀ *P. papatasi* at Lahore, *P. papatasi* at Mir Muhammad, several *P. papatasi* at Peshawar, ♂ *Sergentomyia* sp. at Karnal, several *S. babu* at Dehra Dun, and 2 ♀ *S. s. indica* at Mangowol.

Erythraeid sp. on *P. argentipes* in India.

RELATION TO DISEASE

Several of the sand-fly-borne diseases are zoonoses. The search for vector species therefore involves not only house-frequenting and possibly endophilic species but also wild species which may bite animal reservoirs and possibly man.

Irritation. Sinton (1924*b*) found that sand-flies were an intolerable pest on the north-west frontier and in the Punjab, and that scratching led to secondary infections and the invaliding of troops.

Sand-fly fever. This is caused by at least two types of virus and may have an animal reservoir (Barnett & Suyemoto, 1961). The disease and its only proved vector, *P. papatasi*, are widespread in West Pakistan (Nasir, 1964). Barnett & Suyemoto isolated 39 strains of virus of several types from sand-flies around Peshawar and Rawalpindi, and the number of sand-fly species reported in the present paper shows that further study of vectors is necessary.

Cutaneous leishmaniasis. Oriental sore, due to *Leishmania tropica*, is extremely common in West Pakistan (Nasir, 1964) where it has practically ceased to be a zoonosis (Garnham, 1965). The survey of this subject by Adler & Theodor (1957) suggests that *P. sergenti* is the main vector while other species may attack any animal reservoir that exists. *S. dentata* and *S. grekovi* were found infected with flagellates in burrows of the rodent reservoir in Uzbekistan (Dergacheva & Dolmatova, 1962) but further study of the flagellates is necessary (Theodor, 1965b).

Kala-azar. This disease, due to *L. donovani*, has been found in Baltistan between 2,350 and 2,560 metres above sea level, and its epidemiological pattern seems akin to that of Chinese kala-azar (Ahmad *et al.*, 1960; Ahmad & Burney, 1962; Barnett & Suyemoto, 1961). Barnett & Suyemoto suggested that *P. kandelakii* and *P. chinensis* might be vectors, and the latter has proved more numerous in collections. Mitra (1959) found a few *P. chinensis* in the hilly kala-azar district of Riasi E.S.E. of Rawalpindi (Jacob & Kalra, 1951), but, as in the Chilas and Keris areas, indoor catches were small because people slept out of doors. The occurrence of kala-azar in dry uplands accords with the presence of Palaearctic sand-fly vectors, but is a contrast to most of the kala-azar of India, and Napier (1953) suggested that the disease in Riasi might have been due to an indoor micro-focus.

Kala-azar has been reported from a few lowland areas (Mitra, 1954b; Nasir, 1958) but does not seem to have become established.

Sinton (1924b; 1925b), writing of the Indian kala-azar then known, reported that its western limit, like that of *P. argentipes*, seemed to be the Delhi-Bombay line, and he suggested (1927b) that the disease should be sought wherever this sand-fly was discovered. Indian kala-azar associated with *P. argentipes* occurs in very damp climates with an equable temperature (Napier, 1946; American Geographical Society, 1954; Mitra, 1956, p. 237) and this sand-fly seems unlikely to be a vector in West Pakistan under normal conditions.

ACKNOWLEDGMENTS

I am grateful to many people for their kind help. Professor H. C. Barnett fostered the work by putting his collections at my disposal and initiating my tour in Pakistan. Dr. E. C. Gangarosa, former Director of the Pakistan Medical Research Centre, was responsible for the tour. Its outcome was largely due to the experience and advice of Lieut. Col. Nur Ahmad, Associate Director, who has done much to further the study of leishmaniasis in Pakistan. Mr. W. A. McDonald, Mr. V. McCarthy, Mr. Z. B. Mirza, Mr. M. S. U. Qadri, Mr. Sana Ullah and Mr. J. Muhammad, then of the same Centre, gave valuable cooperation during the tour. His Highness the Wali of Swat afforded facilities in the Swat Valley. Lieut. Col. A. Rashid and Lieut. Col. M. A. Mannan, Agency Surgeons of Gilgit and Skardu Agencies, organized expeditions in those areas. Surgeon Commander M. Ahram provided an assistant at Karachi. Lieut. Col. M. I. Burney gave me the benefit of his experience of kala-azar in Baltistan, and he and Mr. McDonald and Lieut. Col. J. E. Scanlon kindly contributed specimens. Professor O. Theodor gave valuable advice on many taxonomic questions, Professor P. P. Perfil'ev presented specimens of *P. smirnovi*, Dr. B. R. Laurence provided some mites, and Mr. D. Macfarlane examined them.

REFERENCES

- Many early papers dealing with sand-flies in West Pakistan are listed in Sinton's early papers.
- ABONNENC, E. & MINTER, D. M. 1965. Bilingual keys for the identification of the sandflies of the Ethiopian region. *Cahiers O.R.S.T.O.M., Ent. Méd.* **5**.
- ADAMS, A. L. 1867. *Wanderings of a naturalist in India . . .* Edinburgh: Edmonston & Douglas.
- ADLER, S. & THEODOR, O. 1926. On the *minutus* group of the genus *Phlebotomus* in Palestine. *Bull. ent. Res.* **16**: 399-405.
- — 1927. On a collection of *Phlebotomus* sp. of the *minutus* group. *Ann. trop. Med. Parasit.* **21**: 61-68.
- — 1929. The distribution of sandflies and leishmaniasis in Palestine, Syria and Mesopotamia. *Ibid.* **23**: 269-306.
- — 1957. Transmission of disease agents by phlebotomine sand flies. *A. Rev. Ent.* **2**: 203-226.
- AHMAD, N. & BURNEY, M. I. 1962. Leishmaniasis in northern areas of Pakistan (Baltistan). *Pakist. armed Forces med. J.* **12** (1): 1-11.
- — & WAZIR, Y. 1960. A preliminary report on the study of kala-azar in Baltistan (West Pakistan). *Ibid.* **10** (3): 1-10.
- AMERICAN GEOGRAPHICAL SOCIETY. 1954. World distribution of leishmaniasis. *Atlas of Diseases*. Plate 14.
- ANNANDALE, N. 1910. The Indian species of papataci fly (*Phlebotomus*). *Rec. Indian Mus.* **4**: 35-52.
- BARNETT, H. C. & SUYEMOTO, W. 1961. Field studies on sand-fly fever and kala-azar in Pakistan, in Iran, and in Baltistan (Little Tibet) Kashmir. *Trans. N. Y. Acad. Sci.* **23**: 609-617.
- BARTHOLOMEW, J. G., CLARKE, W. E. & GRIMSHAW, P. H. 1911. *Atlas of zoogeography*. Edinburgh: Bartholomew.
- BHARADWAJ, O. P. 1961. The arid zone of India and Pakistan. In L. D. Stamp (Ed.), *A history of land use in arid regions*. U.N.E.S.C.O. Pp. 143-174.
- CHANG, L. T. 1965. Resistance status of *Anopheles sergenti* and its operational importance. World Health Organization Document no. **Mal/482.65**: 37-43.
- CHAUDHRI, W. M. 1965. New mites of the genus *Ledermuelleria*. *Acarologia* **7**: 467-486.
- CHRISTOPHERS, S. R. 1933. *Fauna of British India*, Diptera, IV: Anophelini. London: Taylor & Francis.
- — SHORTT, H. E. & BARRAUD, P. J. 1926. The anatomy of the sandfly *Phlebotomus argentipes*, Ann. and Brun. (Diptera). I. The head and mouth parts of the imago. *Indian med. Res. Mem. no.* **4**: 177-204.
- DARLINGTON, P. J. 1957. *Zoogeography*. London: Chapman & Hall.
- DERGACHEVA, T. I. 1959. On the problem of adaptation of sandflies to various humidities. [In Russian]. *Dokl. Akad. Nauk. S.S.S.R.* **129**: 431-434.
- — & DOLMATOVA, A. V. 1962. On the epidemiology and epizootology of cutaneous leishmaniasis of the rural type in the Karshi Oasis, Uzbekistan. Communication IV. . . [In Russian]. *Medskaya Parazit.* **31**: 206-211.
- DOLMATOVA, A. V. 1962. Differences in ecological requirements of some species of Phlebotominae in the U.S.S.R. *Rep. Sympos. 70th Anniv. V. N. Beklemishev*, Moscow. 456-472.
- — & DERGACHEVA, T. I. 1961. On the epidemiology and epizootology of cutaneous leishmaniasis of the rural type in the Karshi oasis, Uzbekistan, I. . . *Medskaya Parazit.* **30**: 584-591.
- — & ELISEEV, L. N. 1962. On the epidemiology and epizootology of cutaneous leishmaniasis of the rural type in the Karshi oasis of the Uzbek S.S.R. *Revta Inst. Med. trop. S. Paulo* **4**: 65-78.
- FAIRCHILD, G. B. 1955. The relationships and classification of the Phlebotominae. *Ann. ent. Soc. Am.* **48**: 182-196.

- GARNHAM, P. C. C. 1965. The leishmanias, with special reference to the role of animal reservoirs. *Am. Zool.* **5** : 141-151.
- GHAURI, M. S. K. 1965. Notes on Hemiptera from Pakistan and adjoining areas. *Ann. Mag. nat. Hist.* (13) **7** : 673-688.
- GRASSI, B. 1907. Ricerche sui flebotomi. *Memorie Soc. ital. Sci. nat.* (3) **14** : 353-394.
- GRESSITT, J. L. 1958. Zoogeography of insects. *A. Rev. Ent.* **3** : 207-230.
- HEPTNER, V. G. 1938. Origine de la faune désertique du Turkestan et ses particularités zoogeographiques. *Byull. mosk. Obshch. Ispýt Priv.*, N. S. **47** : 338-342.
- HIRST, S. H. 1926. Report on the acari found on or associated with sandflies in India. *Indian J. med. Res.* **13** : 1023-1026.
- HUTCHINSON, G. E. 1934. Report on terrestrial families of Hemiptera Heteroptera. [North India]. *Mem. Conn. Acad. Arts Sci.* **10** : 119-146.
- IMPERIAL GAZETTEER OF INDIA. 1907. **1**. 1931. **26**. Oxford : Clarendon Press.
- JACOB, V. P. & KALRA, S. L. 1951. Kala-azar in Kashmir. *Indian J. med. Res.* **39** : 323-327.
- JENKINS, D. W. 1964. Pathogens, parasites and predators of medically important arthropods. *Bull. Wld Hlth Org.* **30** : Suppl.
- KIRK, R. & LEWIS, D. J. 1951. The Phlebotominae of the Ethiopian region. *Trans. R. ent. Soc. Lond.* **102** : 383-510.
- LANE, F. 1942. Comentários sobre o livro VII de Marcgrave (insetos). In Jorge Marcgrave : *Historia natural do Brasil*. São Paulo : Museo Paulista. Pp. LXXXVIII-LXXXIX.
- LENG, Y.-C. 1964. Some new records of *Phlebotomus* from Hainan . . . *Acta ent. sinica* **13** : 118-128.
- LEWIS, D. J. & McMILLAN, B. 1961. The Phlebotominae of Nigeria. *Proc. R. ent. Soc. Lond.* (B) **30** : 29-37.
- MESGHALI, A. & DJANBAKSH, B. 1961. Observations on phlebotomine sandflies in Iran. *Bull. Wld Hlth Org.* **25** : 203-208.
- & MINTER, D. M. 1960. Internal structural changes in some African Phlebotominae. *Ann. trop. Med. Parasit.* **54** : 351-365.
- LORIMER, E. O. 1939. *Language hunting in the Karakoram*. London : Allen & Unwin.
- LUNDBLAD, O. 1934. Report on Hydracarina. [North India]. *Mem. Conn. Acad. Arts Sci.* **10** : 85-118.
- LUPASCU, Gh., DANCESCO, P. & CHELES, N. 1965. Contribution à l'étude des espèces de phlébotomes (Diptera, Psychodidae) existants en Roumanie. *Archs roum. Path. exp. Microbiol.* **24** : 187-194.
- DUPORT, M., DANCESCO, P. & CRISTESCO, A. 1965a. Recherches sur les espèces de phlébotomes sauvages de Roumanie. *Ibid.* **24** : 195-202.
- — — — — 1965b. Recherches sur les espèces de phlébotomes existants dans la nature en Roumanie. *Proc. XIIth Internat. Congr. Ent.* : 778.
- MANI, M. S. 1962. *High altitude entomology*. London : Methuen.
- MARAINI, F. 1961. *Karakoram*. London : Hutchinson.
- MARTINS, A. V., FALCÃO, A. L. and DA SILVA, J. E. 1964. Estudos sobre os flebotomos do Estado de Minas Gerais. VI. . . *Revista bras. Biol.* **24** : 309-315.
- MATSUDA, R. 1965. The morphology and evolution of the insect head. *Mem. Am. ent. Inst.* no. **4** : 334 pp.
- MAXWELL-LEFROY, H. 1909. *Indian insect life*. Calcutta : Thacker, Spink & Co.
- MESGHALI, A. 1965. Phlebotominae of Bandar Abbas and Jask area. *Bull. Soc. Path. exot.* **58** : 259-274.
- MITRA, R. D. 1954a. Bemerkungen über Sandfliegen (Phlebotomen) . . . *Z. Tropenmed. Parasit.* **5** : 109-113.
- 1954b. Die medizinische Bedeutung der Phlebotomen. *Ibid.* **5** : 307-317.
- 1956. Notes on sandflies. Sandflies of the Poona district. *Ibid.* **7** : 229-240.
- 1959. Notes on sandflies. Sandflies of Punch and Riasi districts of Kashmir, *Ibid.* **10** : 56-66.

- MITRA, R. D. & MITRA, S. D. 1953. A new species of *Raphignathus* (Acarina) associated with *Phlebotomus* in India. *Z. ParasitKde* **15**: 429-432.
- & ROY, D. N. 1952. Notes on sandflies. Part II. *Phlebotomus thapari* n. sp. *Indian med. Gaz.* **87**: 188-193.
- — 1953a. Notes on sandflies, part III. *Ibid.*: **88**: 324-326.
- — 1953b. Notes on sandflies. Part IV. . . . *Ibid.* **88**: 369-372.
- — 1954. *Phlebotomus squamipleuris* var. *poonaensis* nov. var. *Z. ParasitKde* **16**: 191-194.
- MUNIR, A. H. 1963. Observations on the arthropods of medical importance in Gilgit valley. *Pakist. armed Forces med. J.* **13**: 59-63.
- MUNROE, E. 1965. Zoogeography of insects and allied groups. *A. Rev. Ent.* **10**: 325-344.
- MURRAY, J. A. H. 1888. *A new English dictionary*. Oxford; Clarendon Press.
- NAPIER, L. E. 1946. *The principles and practice of tropical medicine*. New York: Macmillan.
- 1953. Kala-azar in Kashmir [review]. *Trop. Dis. Bull.* **50**: 96-97.
- NASIR, A. S. 1958. Sandfly fauna in West Pakistan. *Pakist. J. Hlth* **8**: 21-22.
- 1964. Sandflies as vectors of human disease in West Pakistan. *Ibid.* **14**: 26-30.
- NEWSTEAD, R. & SINTON, J. A. 1921. On a collection of pappataci flies (*Phlebotomus*) from India. *Ann. trop. Med. Parasit.* **15**: 103-106.
- NICOLI, R. M. 1956. Sur la vestiture des Phlebotomidae [DIPT. NEMATOCERA]. *Bull. Soc. ent. Fr.* **61**: 110-113.
- PARROT, L. 1942. Notes sur les phlébotomes. XXXIX. . . . *Phlebotomus fallax*. *Archs Inst. Pasteur Algév.* **20**: 322-335.
- 1953. Notes . . . LXVII.—Les "papilles" des antennes. *Ibid.* **31**: 110-118.
- & CLASTRIER, J. 1960. Notes . . . LXXIII. Phlébotomes du Tassili . . . *Ibid.* **38**: 70-78.
- PERFIL'EV, P. P. 1937.² *Fauna S.S.S.R. Dipterous insects, III, no. 2. Psychodidae (Phlebotominae)*. [In Russian]. Moscow: *Inst. Zool. Acad. Sci. U.S.S.R.*
- 1939. The sand-fly fauna of the U.S.S.R. [In Russian]. *Trudy voenno-med. Akad. R K K A* **19**: 75-95.
- 1941. Data on the sand-fly fauna of the U.S.S.R. [In Russian]. *Ibid.* **25**: 272-283.
- 1960. *Phlebotomus minutus* R. and the species of the group *minutus* (*Sergentomyia*) in the Crimea and Caucasus [In Russian]. *Medskaya Parazit.* **29**: 40-48.
- PRASAD, S. N. & GROVER, P. 1963. The nomenclature of the male genitalia of the cecidomyiids (Diptera—Nematocera). *Marcellia* **31**: 45-58.
- PRATER, S. H. 1965. *The book of Indian mammals*. Bombay: Bombay nat. Hist. Soc.
- PRINGLE, G. 1956. Kala azar in Iraq . . . *Bull. endem. Dis.* **1**: 235-294.
- QUATE, L. W. 1962a. A review of the Indo-Chinese Phlebotominae (Diptera: Psychodidae). *Pacif. Insects* **4**: 251-267.
- 1962b. Psychodidae (Diptera) at the Zoological Survey of India. *Proc. Hawaii. ent. Soc.* **18**: 155-188.
- 1964. *Phlebotomus* sandflies of the Paloich area in the Sudan. *J. med. Ent.* **1**: 213-268.
- QUTUBUDDIN, M. 1944. A report on the sandflies of Hyderabad-Deccan (City) with a short note on a new species. *Indian J. Ent.* **5**: 207-211.
- 1951. The sandfly fauna of the Kohat Valley, N.W. F. P., Pakistan. *Pakist. J. Hlth* **1**: 34-36.
- 1952. A comparative study of the two forms of *Phlebotomus antennatus* Newstead (Diptera, Psychodidae) from Hyderabad, India, and N. W. F. P., respectively. *Proc. R. ent. Soc. Lond.* (B) **21**: 79-82.
- 1960a. Mosquito studies in the Indian subregion. Part I. . . . *Pacif. Insects* **2**: 133-147.
- 1960b. The mosquito fauna of Kohat-Hangu Valley, West Pakistan. *Mosquito News* **20**: 355-361.
- SCHMID, F. 1958. Trichoptères du Pakistan. *Tijdschr. Ent.* **101**: 181-221.

² The 1966 revision was received when this paper was in the press.

- SCHMIDT, M. L. & SCHMIDT, J. R. 1962. Variations in antennal ascoid/segment ratio in *Phlebotomus papatasi* Scopoli (Diptera : Psychodidae). *Ann. ent. Soc. Am.* **55** : 722-723.
- 1963. A morphologic study of *Phlebotomus papatasi* from Egypt (Diptera : Psychodidae). *Ibid.* **56** : 567-573.
- SINTON, J. A. 1922. Entomological notes on field service in Waziristan. *Indian J. med. Res.* **9** : 575-585.
- 1924a. Notes on some Indian species of the genus *Phlebotomus*. Part III. Provisional diagnostic table of the males . . . *Indian J. med. Res.* **11** : 807-815.
- 1924b. Notes . . . VIII. Records of the geographical distribution and the seasonal prevalence . . . *Ibid.* **11** : 1035-1049.
- 1924c. Notes . . . IX. *Phlebotomus simillimus* var. *hospitii* nov. var. *Ibid.* **12** : 261-271.
- 1925a. Notes . . . X. Abnormalities in the appendages . . . *Ibid.* **12** : 467-469.
- 1925b. Notes . . . XI. The rôle of . . . *Phlebotomus* as carriers of disease . . . *Ibid.* **12** : 701-729.
- 1925c. Notes . . . XII. *Phlebotomus argentipes* . . . *Ibid.* **12** : 789-799.
- 1926. Notes . . . XV. *Phlebotomus newsteadi* n. sp. *Ibid.* **13** : 559-563.
- 1927a. Notes . . . XVII. Further records of the geographical distribution. *Ibid.* **14** : 941-945.
- 1927b. Notes . . . XVIII. Miscellaneous notes. *Ibid.* **14** : 947-953.
- 1927c. Notes . . . XIX. The value of the female genitalia . . . *Ibid.* **15** : 21-26.
- 1927d. Notes . . . XXI. *Phlebotomus christophersi* n. sp. *Ibid.* **15** : 33-39.
- 1927e. Kala-azar at high altitudes. *Indian med. Gaz.* **62** : 723.
- 1928a. Notes . . . XXIII. *Phlebotomus clydei* n. sp. *Indian J. Med. Res.* **16** : 179-186.
- 1928b. The synonymy of the Asiatic species of *Phlebotomus*. *Ibid.* **16** : 297-324.
- 1929. The identification and classification of the species of the genus *Phlebotomus*, with some remarks on their geographical distribution in relation to disease. *Trans. 7th Congr. far east. Assoc. trop. Med.* **3** : 172-193.
- 1931a. Notes . . . XXVI. *Phlebotomus eleanorae* n. sp. *Indian J. med. Res.* **18** : 817.
- 1931b. Notes . . . XXVI. *Phlebotomus bailyi* n. sp. *Ibid.* **18** : 821-829.
- 1932. Notes . . . XXX. Diagnostic table for the females . . . *Ibid.* **20** : 55-74.
- 1933a. Notes . . . XXXII. *Phlebotomus dentatus* n. sp. *Ibid.* **20** : 869-872.
- 1933b. Notes . . . XXXIII. *Phlebotomus hodgsoni* n. sp. *Ibid.* **20** : 873-878.
- 1933c. Notes . . . XXXV. Additions and alterations to the diagnostic table . . . *Ibid.* **21** : 225-228.
- 1933d. Notes . . . XXXVI. Diagnostic table for the males . . . *Ibid.* **21** : 417-428.
- SMITH, R. O. A. 1959. Bionomics of *Phlebotomus argentipes*. *Bull. Calcutta Sch. trop. Med. Hyg.* **7** : 17-21.
- STEARNS, W. T. 1960. *Allium* and *Mitula* in the Central and Eastern Himalaya. *Bull. Br. Mus. nat. Hist., Botany*, **2** : 161-191.
- THEODOR, O. 1938. On sandflies (*Phlebotomus*) from Ceylon, Siam, and Malay. *Indian J. med. Res.* **26** : 261-269.
- 1948. Classification of the Old World species of the subfamily Phlebotominae (Diptera, Psychodidae). *Bull. ent. Res.* **39** : 85-115.
- 1952. On the zoogeography of some groups of Diptera in the Middle East. *Istanb. Univ. Fen. Fak. Mecm.* **17** : 107-119.
- 1958. Psychodidae-Phlebotominae. In Lindner, *Fliegen palaearkt. Reg.* 9c : 1-55. Stuttgart.
- 1965a. On the classification of American Phlebotominae. *J. med. Ent.* **2** : 171-197.
- 1965b. Recent research on transmission of leishmaniasis. *Proc. XIIth internat. Congr. Ent.* : 771-772.
- & MESGHALI, A. 1964. On the Phlebotominae of Iran. *Ibid.* **1** : 285-300.
- TING, S.-T. & HO, K.T. 1962. Investigations of the Chinese species of the genus *Phlebotomus*. Part IX. . . [in Chinese]. *Acta ent. sin.* **11** : 388-393.

- UVAROV, B. P. 1938. Ecological and biogeographical relations of Eremian Acrididae. *Mém. Soc. Biogéogr.* **6** : 231-273.
- 1966. Biogeography of Soviet Asia. *Nature, Lond.* **210** : 149.
- VAN EMDEN, F. & HENNIG, W. 1956. Diptera. In S. L. Tuxen *Taxonomist's glossary of genitalia in insects*. Copenhagen : Munksgaard.
- WALTER, R. 1748. *A voyage round the world . . . by George Anson . . .* London : J. & P. Knapton (printers).
- YOUNG, T. C. M., RICHMOND, A. E. & BRENDISH, G. R. 1926. Sandflies and sandfly fever in Peshawar district. *Indian J. med. Res.* **13** : 961-1021.

INDEX TO SPECIES AND SUBSPECIES

(Synonyms in italics)

- | | |
|---------------------------|---------------------------------|
| sp. A, 21 | <i>indica</i> , 34 |
| <i>africana</i> , 28 | <i>kandelakii</i> , 17 |
| <i>alexandri</i> , 15 | <i>keshishiani</i> , 19 |
| <i>antennatus</i> , 27 | <i>latiterga</i> , 42 |
| <i>argentipes</i> , 23 | <i>longiductus</i> , 21 |
| <i>arpaklensis</i> , 25 | <i>major</i> , 21 |
| <i>asiatica</i> , 28 | <i>major</i> , 21 |
| sp. B, 32 | <i>mediensis</i> , 25 |
| <i>babu</i> , 28 | <i>minutus</i> , 25, 27, 28, 39 |
| <i>baghdadis</i> , 30 | <i>montana</i> , 39 |
| <i>bailyi</i> , 38 | <i>niger</i> , 28 |
| <i>burneyi</i> , 17 | <i>nuri</i> , 15 |
| <i>campester</i> , 38 | <i>palestinensis</i> , 34 |
| <i>chinensis</i> , 21 | <i>papatasi</i> , 14 |
| <i>christophersi</i> , 40 | <i>pawlowskyi</i> , 37 |
| <i>clydei</i> , 42 | <i>punjabensis</i> , 27 |
| <i>colabaensis</i> , 24 | <i>sergenti</i> , 17 |
| <i>deccanensis</i> , 27 | <i>sergenti</i> , 15 |
| <i>dentata</i> , 25 | <i>shorttii</i> , 31 |
| <i>glaucus</i> , 24 | <i>simillimus</i> , 43 |
| <i>grekovi</i> , 32 | <i>squamipleuris</i> , 34 |
| <i>hindustanicus</i> , 21 | <i>subtilis</i> , 44 |
| <i>hodgsoni</i> , 37 | <i>theodori</i> , 27 |
| <i>hospitii</i> , 43 | <i>tiberiadis</i> , 44 |

